5-1972

Economic Efficiency of Grazing Systems

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ECONOMIC EFFICIENCY OF GRAZING SYSTEMS

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Economics

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1972

ACKNOWLEDGEMENTS

I wish to thank Dr. John P. Workman, who supervised and scrutinized this study. He also arranged for financing through Utah Agricultural Experiment Station Project Hatch 690. The final product owes much to his devotion for objectivity, clerity and detail. Dr. Bartell C. Jensen's advice, encouragement and arrangement for financial assistance from the Department of Economics is appreciated. Dr. Kenneth S. Lyon spent numerous hours on logistics and helping me design the Theoretical framework. Other members of the doctoral committee: Dr. Darwin B. Nielsen and Dr. Herbert H. Fullerton provided very useful comments.

I am thankful to the Government of Pakistan and Food and Agricultural Organization of the United Nations for enabling me to come to the United States of America. I also wish to record my appreciation to Dr. Jack F. Hooper for suggesting the topic to me and for his encouragement throughout my period of stay in the U.S.A. Cooperation from the Bureau of Land Management officials and ranchers is also appreciated.

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ABSTRACT

Economic Efficiency of Grazing Systems

by

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Benefits and costs of implementing the specialized grazing systems on federal rangelands managed by the Bureau of Land Management (BLM) were studied. First only the direct benefits and costs were used to determine the internal rates of return on the Bureau of Land Management investments in grazing systems. Secondly, the effects of these systems on profits of private ranchers were determined. Finally the benefits and costs stream of the Bureau of Land Management and the changes in ranchers' profits were brought together to find out the net gain to society from investing the federal funds in specialized grazing systems.

The internal rate of return on the Bureau of Land Management investments over an area of approximately 695,024 acres in Idaho, Nevada and Utah is 2.37 percent which is less than half the rate federal investments are expected to return (as measured by the federal government's cost of borrowing). More than half of the twenty four allotment plans have negative rates of return. Out of thirteen plans with negative rates of return only five have positive net returns and the rest have negative net returns.

Specialized grazing systems have improved the aggregate profits of the private ranchers by \$.036 for each pound of livestock produced. Federal investment in specialized grazing systems may be justified if income distribution is considered a valid reason for such activities. If the stability and continuity of their operations is assured, ranchers may be able to pay increased grazing fees. In view of the fact that under public pressure the government has decided to withdraw rancher benefits in the form of grazing fees lower than market rates, income distribution appears to be poor grounds for justification of federal investment. Also, given the income benefits to ranch operations, ranchers themselves would undoubtedly want to invest in grazing systems on federal land. However, rancher investment is unlikely since the Bureau of Land Management is already discouraging private permanent improvements on public lands.

From the point of view of the Bureau of Land Management as a proprietory agent, the real cost of obtaining an increase of a bundle of non-grazing benefits produced jointly with an animal unit month of increased forage production is \$0.53. A grazing fee of \$1.74 per animal unit month would be required for the Bureau of Land Management to break even on investments in grazing systems. This is in spirt of the fact that large federal investments in necessary range improvements already existed before the implementation of the specialized grazing systems. It appears the investments in grazing systems on unimproved ranges are not justifiable in terms of direct returns to the Bureau of Land Management.

If the externality to the ranching segment of society is internalized, specialized grazing systems more than pay for themselves if future benefits are discounted at the public discount rate. Besides the positive change in public goods, society gains \$3.42 for each additional animal unit month of grazing. Many questions are left unanswered such as quantifying and placing a dollar value on rangeland benefits claimed by the federal agencies.

(97 pages)

CHAPTER I

INTRODUCTION

In 1970, there were 762 million acres of federally owned land in the United States. The Bureau of Land Management (BLM) has exclusive responsibility for administrating about 60 percent or 451 million acres of this federally owned land. More than half of this area is in the State of Alaska. The second largest managing agency for federally owned lands is the Forest Service with jurisdiction over 24 percent of the acreage (United States Department of Interior, 1971, p. 1).

In the 11 western coterminous states approximately 273 million acres of federal lands are grazed. The public lands provide about 12 percent of total forage consumed by livestock in the 11 western states and about 3 percent of the total forage consumed in the entire United States (Public Land Law Review Commission, 1970, p. 105). The very existence of many ranches as economic units depends on the availability of public rangelands. Grazing has been the largest single economic use of public lands. In 1969, the Bureau of Land Management collected $5,379,253 from 175,629,189 acres excluding Alaska (United States Department of Interior, 1971, p. 86). Revenue collections will increase sharply with implementation of scheduled increases in grazing fees.

Grazing on public lands occurs at different seasons of the year depending on vegetation, elevation of the area and climatic conditions. Generally foothills serve as sources of spring and fall forage. Mountain ranges are grazed in summer and desert ranges in the winter. There is an integral relationship between public rangelands and private ranching operations. Therefore, policies of the agencies managing public lands affect the entire ranching operations. The objective of BLM range management practices is to "obtain high level sustained yields of forage for use by livestock and wildlife in balance with conservation needs and other multiple uses of land." (BLM, 1965, p. 4112.1). As a policy of the BLM, "management of livestock will be accomplished as a part of the Bureau's continuing program through either (1) an acceptable allotment management plan or (2) designation of a grazing system for the allotment or management area." (BLM, 1968, p. 15). For each management plan, a grazing system[1] is required and must be described (BLM, 1968, p. 4112. 15Cla). The 1970 Budget of the United States (U.S. President, 1970, p.552) listed the implementation of allotment management plans incorporating "Advanced Grazing Systems" as one of the activities of BLM for which funds are appropriated. The 1971 Budget curtained the new plans, but old ones were allowed to be implemented (U.S. President, 1971, p. 536). Conventionally livestock have had free access to any part of the range. This is referred to as a continuous grazing system. However, the continuous grazing system is not meant to be the one prescribed and described in the agency manuals. This is evidenced by Appendix A, where examples of grazing systems are reproduced from the BLM Manual and allotment plans. In practice, therefore, all the new systems are based on some kind of rotation or deferment of use. These grazing systems are based on principles of plant physiology and ecology (Appendix A). The systems are designed to optimize forage and livestock production subject to the constraint of not infringing upon other uses of public lands. The many advantages listed for specialized grazing systems are all directed toward

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[1]For definition of technical terms, see Appendix G.

the ultimate objective of increasing plant cover and forage production. Not much is known about the cost of such increases. Since the Classification and Multiple Use Act of 1964 (U.S. Congress, 1970, 18§§ 528-31) the management plans include a paragraph or two on description of multiple uses and the plans are held responsible for maintenance of such uses.

Each specialized grazing system is a new technique or a modification of previous technique of forage and livestock production on public ranges. Private ranchers conform to these rules of management with mixed reactions. Favorable reaction can be interpreted to indicate higher private profits or the desire to avoid confrontation with the administrative agencies. Opposition to grazing systems may be due to resultant lower profits or simply to general resistance to change by a conservative sector of the society.

Implementation of a grazing system involves additional costs on the part of both federal agencies and private ranchers. Fences are required to divide a range area into a number of units. Livestock are then periodically moved during the grazing season according to a predetermined program designed to provide the requirements of both livestock and plants. The erection of cross fences necessitates additional water developments, salting and increased livestock movements and creates a forced feeding situation in the fenced units.

This study investigates (a) returns to federal investment in grazing systems; (b) effects of grazing systems on profits of private ranchers; and (c) the real cost of nongrazing benefits to (1) the BLM, and (2) the society at large.

Grazing systems in retrospect

The idea and even the practice of specialized grazing systems are not new. Although August L. Hormay's controversial work in Harvey Valley brought the specialized systems into the limelight in the 1950's, the Forest Service had advanced the idea of deferred grazing as early as the beginning of the century. The list of studies on the advantages and disadvantages of specialized grazing systems is impressive, but they are all concerned with biological aspects of rangelands and absolute amounts of forage and livestock production. No systematic effort has been made to determine the profitability of the systems.

Studies differ on the results attributed to rotational grazing systems. Earlier controversies were reported in part by Stoddart and Smith (1955). An excellent review of performance of grazing systems is given by Heady (1961). Abstracts and excerpts from one hundred and fifteen studies on grazing management systems from 1895 to 1966 have been published by the U.S. Forest Service (1968). Most of these studies, which indicate superiority of specialized grazing systems in total forage and livestock production, also imply higher profits without any economic basis. Even the relatively recent studies are not unanimous in their views on grazing systems. An examination of twenty-nine studies on grazing systems by the Forest Service revealed that:

1. In 12 studies, livestock weight gains were greater under continuous grazing as compared to some other systems.
2. In 8 studies, livestock weight gains were greater under a specialized system as compared to continuous grazing.
3. In 9 studies, there was no appreciable difference in weight gains of livestock under continuous grazing as compared to some other systems.
4. Results of these studies showed no consistent relationship between livestock responses, a specific grazing system, and a particular kind of vegetation. Local conditions, such as quantity and quality of vegetation, the management history of the animals, and the season apparently have profound effects on how animals respond to a system and to the vegetation of the area.
5. Thirty-nine studies compared the responses of vegetation measured by increases and decreases of desirable species

> under continuous grazing versus some other systems . . . In three studies, vegetation improved under continuous grazing. In 31 studies vegetation conditions declined under continous grazing as compared to other systems. In five studies there was no difference in vegetation under continuous and specialized systems of grazing. (U.S. Forest Service, 1967, p. 25)

Biswell and Foster (1947) reported no appreciable differences in forage density, species composition, or utilization as a result of rotation grazing systems in switchcane (Arundinaria tecta) areas in eastern North Carolina, nor were there any significant differences in cattle weight gains under three systems; viz., (1) mid-season rotation grazing; (2) twenty-eight day rotation grazing; and (3) continuous grazing.

Dillon (1958) summarized the results of an eight-year study of a deferred rotation system near Harrington, Washington, as follows:

1. The system corrected a bad distribution problem.
2. It was possible to get improvement over all the ranch, even though the key grasses had a different season of use.
3. An even utilization of practically all forage.
4. A 100 percent increase in carrying capacity.
5. The quality of forage improved as reflected in heavier calves.

Dillon and Wallenmeyer (1966) further report deferred grazing as a means of improving range conditions. Hinton (1963) listed the following reasons for range rotation:

1. Desirable plant species are given a chance to establish vigor.
2. Seed production of desirable plants is improved.
3. More uniform utilization
4. Poor plant species are used to some extent.
5. Increased plant cover enhances watershed values.
6. Poisonous plants can be avoided by deferring use until they are safe.

7. Less riding is needed for distribution.

Fisher and Marion (1951) in a six-year study on rest rotation grazing on buffalo grass at the Agricultural Experiment Station, Spur, Texas, found that continuous grazing gave more uniform steer gains than rotation grazing. A similar pattern was found in basal cover increases.

Hubbard (1951) found conservative continuous grazing the most practical method of pasture use in western Canada, although increases in forage production were recorded from clipped plots under simulated rotational grazing.

According to Hormay and others (1958, 1969) a rest rotation grazing system on the Harvey Valley cattle allotments was designed to remove the harmful effects of selective grazing by resting the range from grazing at appropriate intervals; and, thereby, to increase forage and livestock production. Rest rotation was said to improve the range condition. Construction of fences, water developments, and other grazing management facilities were listed as tools used for implementing the system; and no mention was made of the costs of these tools.

Anderson (1940) reported an average of 65.1 pounds of beef per acre per grazing season on deferred pastures in Kansas compared to 37.4 pounds for the two season-long pastures. Deferred grazing also provided protection against runoff and erosion during winter and spring.

Lodge (1970) has listed studies indicating that special grazing systems were more effective in restoration of overgrazed ranges than in increasing productivity of ranges in highly productive conditions. He also said that some modifications in delaying use, etc., are superior to continuous grazing.

It is not uncommon to find statements resembling the one from Morris (1932, p. 211), "The additional expense required in fencing was more than offset by the increase in forage. It was found that the acreage required for one head of stock could be reduced to 5 acres where it formerly took 7 acres." Range was said to show as much as 53 percent increase in abundance of wheatgrass and a like increase in other valuable forage plants and a 36 percent increase of forage.

Quite often implementation of a grazing system is confused with other improvement practices. This confounds the ensuing benefits. Bay (1964) reported that (1) development of watering points; (2) implementation of rest rotation grazing systems by building fences; and (3) spraying for weeds and brush were responsible for 10 percent more cattle run on the forests. Earlier, Frandsen (1950) categorized the management practices as:

(a) Forage management practices

(b) Facilitating and enabling practices

(c) Special forage improvement practices.

Under (a) above was noted rotation and deferred grazing, proper utilization, and fire prevention and protection. Stock water development, fences, salting, and feed reserves were included in category (b). Brush control, fertilization, and seeding were included in the last category. It was not made explicit whether fencing and watering are separate management practices or an accessory of grazing systems.

Workman and Hooper (1968) found fencing an unprofitable venture for getting better livestock distribution in mountain range areas in a study area covering 25,000 acres. They found guzzlers economical for private investment only. Trail building and ponds paid off for both federal and private investment. Water development, fencing, salting, and trail building are also tools of implementing grazing systems. Water development and trail building will be carried out even without specialized systems, because they are found to be economical. Then the question arises as to how the necessary components of grazing systems are identified. It seems appropriate to surmise that if such tools were not used earlier, but were used with the initiation of a grazing system, they must be required for the system. Thus, the assumption can be made that a grazing system is the cause of introducing these distribution and improvement practices, and their costs should be included in the cost of implementing the grazing system.

Ratliff, Reppert and McConnan (1969) found that in 15 years of practice of rest-rotation grazing in the Harvey Valley allotment, it cost the Forest Service 19 percent more than season-long grazing should have cost. An increase of 50¢ per Animal Unit Month in grazing fees would have been required to break even. Rest-rotation cost the permittees 28 percent more than season-long grazing would have cost. About two thirds of the cost was from weight losses in late season due to forced feeding characteristics of the system.

A good description of the allocation of grazing permits by the Forest Service and Bureau of Land Management is given by Gardner (1963b). In spite of any misallocation of grazing permits as brought out by Gardner (1962), the new management plans incorporating rotational grazing do not claim to rectify this. Thus, the performance of any specialized system needs to be tested with the existing levels of allocative efficiency. Determination of the cost of this misallocation is a separate problem. Martin and Jefferies (1966) doubted that misallocation could be the whole reason for divergence between actual and expected values of grazing permits.

Notwithstanding the dependency and commensurability requirements along with priorities of use pointed out by Gardner (1962), the existence of markets for range permits was proved by Roberts (1967) and Jensen and Thomas (1968). One would expect the effect of the federal agencies' decision on a grazing system to be reflected in changes in permit values and values of private base property similar to increases in land prices under Tobacco Acreage Controls estimated by Hartman and Tolley (1961). However, the recommendations of the Public Land Law Review Commission (1970) asking that a fair market value be charged for grazing public lands and the subsequent hike in grazing fees by the Department of Interior and Department of Agriculture, raises serious questions as to whether the permit values will now reflect the true divergence between effective marginal value product and marginal factor cost on federal grazing lands. Hence, the approach followed below appears appropriate since all the direct and indirect costs of the ranch operators must be considered.

CHAPTER II

THEORETICAL PROBLEM

Since there are many direct and implied benefits provided by vegetation on public lands, there is a tendency to identify the forage produced as a social, collective, or public good.[1] A closer look at public lands, their products, and their relationships confirms the abundance of public goods on these lands. Yet all is not of the nature of public goods. There are goods which are public and there are those which are private. Also, there are goods which are both. Forage available on public rangelands comes under the latter category. It is a private good when sold freely in the market, competing with other sources of supply. This legitimacy of being a private good is derived from its being an input in livestock production. The market value of livestock produced by ranchers on these lands is in no way shrouded in mysterious clouds of social goodness. At the same time it is a public good when every American can derive satisfaction from a well-preserved and "natural" landscape, and

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[1]Social, collective, and public goods are different terms for non-private goods with slight variation in meanings attached by the expositor of each definition. Samuelson (1954, p. 387) defined private goods as those "which can be parcelled out among individuals" and collective goods as those "which all enjoy in common ...." In extension of this treatment Samuelson (1958, p. 335) offered three categories: pure private goods, pure public goods, and a mixed model. He defined public goods as "simultaneously entering into many person's indifference curves." Musgrave (1969, p. 798) reviews definitions of social goods from Wicksell and Lindhal's writings as those "the consumption of which is non-rival."

In this study, the term public goods will be used to include all goods which are not purely private. Any departures from these two categories will be dealt with separately outside the scope of these terms.

merely knowing that these things exist somewhere in the west. Plants, in their capacity as public goods, also provide habitat to organisms, wildlife, and consuming or intruding man.

The mixture of goods and their production possibilities can be made more explicit by the following exposition.

Let X_i be the inputs at the disposal of the BLM which can be potentially used for range forage production for domestic livestock. There can be B_i sets of goods produced involving F_i production functions, where i = 1 to m. The ith set is produced by ith production function. One of these sets (B_1) is composed of the goods produced in the range enterprise. These sets can be defined as below:

$S_1 = \{B_1,...,B_m\}$, a set of competitive enterprises

$B_1 = \{Q_1,...,Q_j\}$, a set of jointly produced goods where Q_1 is forage production

$\tilde{B}_1 = \{Q_2,...,Q_j\}$

$B_2 = \{Q_{j+1},...,Q_n\}$, a set of goods which are produced using Q_1 in addition to X_i. They compete with livestock production for Q_1 after initial stages of complementarity and supplementarity.

The elements of set S_1 can be described as potential rivals in the use of range land; such as, forage, timber, surface mining, campgrounds, and even homesites. B_1 is comprised of a set of jointly produced goods; such as, forage, pure water, stable soil, wildlife habitat, and soil organic matter. Range land serves in a dual capacity; viz., as an input in forage production and as home for the users of forage. Similarly, plant species which produce forage serve as a direct input in the form of food for livestock and other animals and also provide cover for wildlife of all kinds.

Different species of game animals which use range forage as a direct input fall into the category of goods produced under B_2. Since this study is limited to cattle only, other domestic livestock allowed onto federal rangelands are also elements of this set of goods. Different animals prefer different plant species and plant parts. Big game and domestic livestock do not compete for the same plant materials with moderate stocking rates. At lower stocking rates the two types of animals increase the available forage supply for each other by affecting intraspecific competition between plants. However, animal competition for forage sets in as the stocking rates increase and the seasons of range use by livestock are prolonged. The initial complementary and supplementary relationships between big game and cattle were studied by Smith and Doell (1968, pp. 1-32) and between sheep and cattle by Cook (1954, pp. 10-13). Hopkin (1954, pp. 170-5) used Cook's results to draw some economic conclusions about the supplementary and competitive ranges.

Since the rate of production of public goods is not determined in the market, assume the rate of production of goods produced in B_2 fixed at $B_{2,0}$ by a socio-political pressure mechanism. This would require setting aside a fixed rate of forage for this purpose. The residual is the supply of forage to the ranching industry. Also assume that the rate of production of goods in $\tilde{S}_1$, that is $(B_3,\ldots,B_m)$ is fixed at a level that does not interfere with the use of forage by domestic livestock.

Let

Q_1 = total forage produced on federal ranges

$Q_{1,0}$ = forage reserved for B_2

$Q_{1,L} = (Q_1 - Q_{1,0})$ = forage supply for production of domestic livestock

$\tilde{B}_1 = f\ (X_i,\ Q_1)$

A specific rate of Q'_{1L} is leased to ranchers after all the considerations for B_2 have been met. The rate of $Q'_{1,0}$ and consequently that of $Q'_{1,L}$ was established at the time of adjudications.[2] The practice has been to quantify AUM's of $Q_{1,L}$ in terms of both livestock numbers and grazing season length. $Q_{1,0}$ has not received a similar treatment. The new management plans do attempt to bridge this gap, but still the ultimate problem of quantifying all products in B_2 has not been tackled and the boundary between $Q_{1,0}$ and $Q_{1,L}$ may be somewhat blurred. $\tilde{B}_1$ (the goods jointly produced with Q_1) are still at a very primitive stage of quantification. However, their quantification can be circumvented by concentrating on the measurement of changes in Q_1 because positive changes in $\tilde{B}_1$ occur with increases in Q_1. Therefore, any changes from $Q'_{1,L}$ to $Q''_{1,L}$ indicate an increase in production of $\tilde{B}_1$. This is synonymous with measuring a change of Q'_1 to Q''_1 in order to draw conclusions about the behavior of $\tilde{B}_1$.

In spite of considerable evidence that grazing systems, as an exante concept, are meant to increase forage for livestock in the form of

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[2]The $Q'_{1,L}$ rate of Q_1 is called a class I grazing permit. Adjudication was not carried out at the same time for all rangelands. In some grazing districts it is still going on. However, uniformity is attained in the sense that grazing systems have invariably been started on the allotment where adjudication was already completed. (See Definition of Terms, Appendix G)

immediate increases in permitted numbers or avoiding cuts in permits together with maintaining all other uses at their existing levels, the motives behind grazing systems initiation can be delineated as below:

1. Increase in Q_1 (livestock forage)[3]
2. Increase in $\tilde{B}_1$(goods produced jointly with Q_1)
3. Increase in both Q_1 and $\tilde{B}_1$.

The choice between 1 and 2 above is a function of pressure groups and the subjective evaluation of these pressures. The third choice is a convenient, but relevant afterthought for most administrators.

The stage is now set for investigating the relevant economic aspects of the choice situations 1, 2, and 3 above. In all three cases the existence of three interest groups are assumed.

1. BLM as a proprietory agent of the U.S. government managing one of the government's enterprises: a case of public enterprise
2. The private ranchers: a case of private enterprise using a product of public enterprise
3. BLM as an agent of the sovereign: a case of public finance.[4]

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[3]This can be confirmed from most of the management plans incorporating the grazing systems. Each plan describes the range, records the past and present grazing use, and lays down a certain level of forage production as its objective. Usually a paragraph appears for description of other uses, but generally no more than this. These plans are available from the BLM district offices.

[4]BLM as an agent of the Sovereign is assumed to be responsible for all social costs and social benefits. The government of the United States is the sovereign. Public enterprises are a subset of the activities of the sovereign. As a proprietory agent, the BLM is responsible for direct internal benefits and costs only.

BLM as a proprietory agent

Under the assumption of being a proprietory agent of the government, the BLM is responsible for explicit statements of benefits and costs. Working within the assumption of the BLM goal of increasing Q_{1L}, benefits include only additional revenue accruing to the BLM from increased AUM's of forage. The additional revenue is based on a set of administered prices. Congress has agreed in principle that administered prices will recover the full market value of forage from grazing lands. Though efforts are underway to raise the administered prices to a level dictated by the market prices, it will take a few more years to achieve this. A case can be made against the advisibility of ranking the investments where arbitrary prices are administered. But in the case of forage from public land, since the need to change the prices has been recognized and progress is being made towards this end, it is imperative that we use the actual prices in practice (whether administered or market determined). One of the explicit techniques of ranking investments is the internal rate of return. More will be said about this in Chapter III. For the objective of producing forage for livestock, changes in $\tilde{B}_2$ are external to the BLM in its role as a proprietory agent. Similarly, any effects on profits of ranchers cannot be included in the benefits category under the proprietory role of the BLM. As we shall see later, the products other than forage are freed from the externality label when the assumptions about the role of the BLM are relaxed.

For the BLM as a proprietory agent with an objective of increasing jointly produced public goods, any production of $\tilde{B}_1$ involves the production of a joint product, $Q_{1,L}$, which is sold in the market and which offsets some of the cost of producing $\tilde{B}_1$. This still leaves effects on ranchers' profits as an externality which cannot be counted as a benefit under the assumed proprietory role of the BLM. The changes in the elements of the set $\tilde{B}_1$ are not described in conventional economic units. An increase in Q_1 also indicates increases in $\tilde{B}_1$. The exact determination of the function $\tilde{B}_1 = f\ (Q_1)$ is not available for all the elements of $\tilde{B}_1$. However, in the bargaining process for acquiring more federal funds, such relationships are used and can, therefore, be determined by a subjective evaluation of technical and non-technical relationships by BLM officials and the supervising congressional authority. Any cost of increasing Q_1 and, thereby, $\tilde{B}_1$ is expressed as a per unit cost of the additional Q_1, since the changes are in lump sum quantities. Any returns from the sale of the joint product (Q_1) can then be deducted from this cost to determine the real cost per unit of the increase of Q_1.

The behavior of the BLM as a proprietory agent with an objective of increasing both forage for livestock and jointly produced goods and the treatment of costs and revenues do not differ from that of the BLM working for the objective of increasing $\tilde{B}_1$.

Private ranchers using forage from federal lands

Any BLM actions not only change the supply of forage, but also the method of its use in production of livestock. The BLM actions are unlikely to affect the prices of inputs of livestock production on federal rangelands. The only exception may be the price of forage. This is not likely, due to two reasons. First, grazing allotments received cuts at the time of adjudications which preceeded the implementation of grazing systems and present attempts are restoring these cuts. Second, the forage from public lands, though an important source of supply in the western states, is a small part of the total supply of forage.

Changes in rates of outputs and inputs occur over time throughout the business world. Temporal changes in use of inputs must be recognized before the changes due to exogenous factors such as the BLM decisions can be detected. To illustrate this point, let us assume a rate of use of inputs before the introduction of grazing systems as $X_{i,0}$, so that a rate of livestock production of Y_0 is achieved.

After implementation of the systems, we detect Y_1 rate of production using $X_{i,1}$ rate of inputs. Part of this change $(Y_1 - Y_0)$ will be due to change in inputs $(X_{i,1} - X_{i,0})$, and part due to a shift in the production function. Using the same amounts of inputs, higher output is achieved. Y_1', production of livestock after implementation of grazing systems using $X_{i,0}$ rates of inputs, will have to be compared with Y_0 to detect the latter effect. Determination of this change provides an answer not only to the ranchers' acceptance or rejection of grazing systems, but also provides a missing link in the stream of benefits and costs in the analysis of the BLM's role as an agent of the society at large.

BLM as an agent of the Sovereign

BLM's last (but not the least important) responsibility as an agent of the society at large, demands that all social benefits and costs be reckoned within any benefit-cost analysis. To elucidate the economic behavior of the BLM in this regard, it is necessary to treat the determination of benefits as a political process. In this role, the BLM counts three forms of benefits:

1. Increased Q_1 leading to an increase in grazing fee revenue
2. Increased $\tilde{B}_1$

3. Increased income of ranchers due to changed technical relations between inputs and outputs.

Numbers 1 and 3 above can be expressed in dollars. The $\tilde{B}_1$ are not quantifiable in conventional economic units. We can, however, go a step further than we did while considering the BLM a proprietory agent with the objective of increasing Q_1 and $\tilde{B}_1$ or both. The real cost of additional $\tilde{B}_1$ associated with the increase of $Q_{1,L}$ will be further reduced if the effects on incomes of private ranchers are positive.

CHAPTER III

THE MODEL

Rate of return on the public enterprise

The measuring stick of success of investment of federal funds by the BLM as a proprietary agent of the U.S. will be the internal rate of return. It can be defined as that rate "which discounts future earnings of a project down to a present value equal to the project cost." (Dean, 1954, p. 128) It is based on the principle that in making an investment outlay we are buying a series of future annual incomes. It is generally calculated by solving for i in the equation

$$I = R \left[\frac{1 - (1 + i)^{-n}}{i} \right]$$

where I = cost of original investments in improvements

R = annual net revenue

n = time period for which R is received

i = internal rate of return.

The right hand side of the above equation is the present value of the net annual returns. The internal rate of return is that discount rate at which the present value of the net cash flows is zero. That is

$$R \left[\frac{1 - (1 + i)^{-n}}{i} \right] - I = 0.$$

In spite of wide variation in use of techniques of determining rates of return, it is not uncommon to find the use of internal rate of return in studies of investments in natural resources (Gardner, 1961, 1963a; Workman, 1970; Neilsen, 1967). Gardner (1963a) deplored the diversity of techniques and recommended the use of the internal rate of return as a standard technique.[1] The BLM's investment in grazing systems has its immediate competitors not in corporate activities of the private market, but in other investment opportunities of the BLM. Next in line are the federal projects by other agencies of the Department of Interior and other U.S. Departments in order of decreasing relevance for comparisons. The BLM's expenditure on grazing systems is a small part of total developmental funds budgeted by the political process.[2] Estimation of an explicit rate of return is thus required for ranking purposes. In the treatment of the BLM as a proprietary agent, externalities are left out to be considered by the political process. Thus, increased revenue from grazing fees will be the only benefit included in the ranking process.

Without offering further excuses for using this very prevalent, but also much disputed technique of ranking investments, it needs to be pointed out that the uniqueness of this study is not in the technique being used, but in the area of its application.[3]

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[1]There can be multiple internal rates of return for projects with large negative cash flows towards the end of their life. Gardner (1963) cautioned against this possibility, but dismissed it on the ground that it is not likely in range improvements. Arrow and Levhari (1969) and Flemming and Wright (1971) wrestled with the same problem by suggesting that for projects whose life can be costlessly truncated to maximize their present value, the internal rate of return will be unique, that is, the maximized present value is monotomic decreasing function of the discount rate. The internal rate of return method assumes the reinvestment of returns from projects of different life spans at the internal rate of return to achieve a common terminal date.

[2]In 1970, out of a total budget outlay of $1,953 billion by the U.S. Government, the BLM was allocated $53,980 thousand. The range management program was estimated to cost $5,234 thousand (United States President, 1970).

[3]The major rival technique to the use of internal rate of return is the present value method. See Hirshleifer (1959).

Changes in profits of private ranchers

For the ranching firms involved in livestock production, profit is the difference between revenues and costs. This can be written as

$$\Pi = P_y(Y) - P_1X_1 - P_2X_2 - P_3X_3$$

Assuming a Cobb-Douglas production function

$$Y = A\ (X_1^{\alpha_1}\ X_2^{\alpha_2}\ X_3^{\alpha_3}\ )$$

Y = pounds of livestock sold

P_y = price of product Y

P_i = price of factors X_i, where i = 1, 2, and 3

X_1 = fixed capital

X_2 = working capital

X_3 = labor

The α_i are assumed to be fixed for the firms within the industry.

The advanced grazing systems developed and implemented by the BLM are of the nature of exogenous technology from the viewpoint of private ranchers. This comes about because of the BLM's investment, plus regulation of the format of production processes using the same combination of inputs. Actions of the BLM can be made a function of time; and, thus, any changes in the production function can be depicted as

$$A(t)\ (X_1^{\alpha_1}\ X_2^{\alpha_2}\ X_3^{\alpha_3}\ ).$$

This is a comprehensive scheme to measure all changes exogenous to firms. However, for the specific problem of measuring the effect of BLM action in the form of specialized grazing systems, it will suffice to assume a discrete change from time period 0 to 1, during which the grazing systems have been implemented. Then,

$$Y_0 = A_0 \, (X_1^{\alpha_1} \, X_2^{\alpha_2} \, X_3^{\alpha_3})$$

$$Y_1 = A_1 \, (X_1^{\alpha_1} \, X_2^{\alpha_2} \, X_3^{\alpha_3})$$

Assuming no change in relative prices, the prices of the base year (1965) can be inflated by a price index to match those of 1970. Using the same levels of inputs and constant prices overtime, the change in profit can be written as

$$\Delta\Pi = [P_y \; Y_1 \; - P_1X_1 - P_2X_2 - P_3X_3] - [P_y \; Y_0 - P_1X_1 - P_2X_2 - P_3X_3]$$

$$= P_y \; (A_1X_1^{\alpha_1} \, X_2^{\alpha_2} \, X_3^{\alpha_3}) - P_y \; (A_0X_1^{\alpha_1} \, X_2^{\alpha_2} \, X_3^{\alpha_3})$$

$$= P_y \; (X_1^{\alpha_1} \, X_2^{\alpha_2} \, X_3^{\alpha_3}) \; (A_1 - A_0)$$

$$\frac{\Delta\Pi}{Y_0} = \frac{P_y \; (X_1^{\alpha_1} \, X_2^{\alpha_2} \, X_3^{\alpha_3}) \; (\Delta A)}{A_0(X_1^{\alpha_1} \, X_2^{\alpha_2} \, X_3^{\alpha_3})} = \frac{\Delta A}{A_0} \cdot P_y$$

$\frac{\Delta A}{A}$ can be estimated as below.[5]

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[5]This is adopted from Solow (1957). He showed that a technical change in a Cobb-Douglas production function $Q = A\,(t)\,(KL)$ with $A\,(t)$ measuring accumulated affect of shifts overtime can be estimated from changes in output and inputs if the production function is known. Differentiating totally with respect to time and dividing by Q, he gets

$$\frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + \frac{\partial Q}{\partial K}\frac{K}{Q}\frac{\dot{K}}{K} + \frac{\partial Q}{\partial L}\frac{L}{Q}\frac{\dot{L}}{L}$$ when dots indicate time derivatives.

By rearranging this equation, we obtain $\frac{\dot{A}}{A} = \frac{\dot{Q}}{Q} - \frac{\partial Q}{\partial K}\frac{K}{Q}\frac{\dot{K}}{K} - \frac{\partial Q}{\partial L}\frac{L}{Q}\frac{\dot{L}}{L}$.

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha_1 \frac{\Delta X_1}{X_1} - \alpha_2 \frac{\Delta X_2}{X_2} - \alpha_3 \frac{\Delta X_3}{X_3}$$

In this equation α_1, α_2, and α_3 are unknows. In a Cobb-Douglas production function, coefficients α_i of the log form of the function can be estimated by the least squares method. This is quite straight forward if the X_i come from an experiment. However, in the market situation we are dealing with amounts of X_i are dependent on each other, which may inflate the sample variances (Johnston, 1963, p. 179). Therefore, the Best Linear Unbiased Estimator properties of classical least squares regression do not hold. That is, the expected value of matrix e e$'$ is not equal to $\sigma^2 I$, where e is a vector of disturbances. This problem can be overcome by assuming that the sampling error is the same function of the disturbance vector e as the estimator itself is of the independent vector Y. Then the least squares estimator is still the Best Linear Unbiased Estimator (Theil, 1971, p. 119). Aitken's generalized Gauss-Markov least squares theorum can, therefore, be applied to estimate a positive definite matrix Ω, so that the Best Linear Unbiased Estimator can be found. That is,

$$b = (X' \Omega^{-1} X)^{-1} (X' \Omega^{-1} Y)$$

and the variance $\Sigma_{\overline{bb}} = \sigma^2 (X' \Omega^{-1} X)^{-1}$

where X is a matrix of independent variables, Y is a vector of dependent variables, and Ω is a nonsingular variance-covariance matrix of the disturbance term.

This estimator is the classical least squares estimator in a transformed problem (Goldberger, 1964, p. 233). However, since we are unable to say anything about the variance-covariance matrix of the disturbance term, we cannot rely on Aitken's generalized Gauss-Markov least squares theorum. To eliminate these problems the factor shares method is employed in this study to estimate α_i. This was earlier used by Klein, and then further developed by Nerlove (Nerlove, 1965, p. 65). The following method gives consistant and unbiased estimates of α_i.

$$\text{Ln } \alpha_1 = \frac{1}{F} \sum_{f=1}^{F} \frac{P_{1f} \cdot X_{1f}}{P_{yf} \cdot Y_f}$$

$$\text{Ln } \alpha_2 = \frac{1}{F} \sum_{f=1}^{F} \frac{P_{2f} \cdot X_{2f}}{P_{yf} \cdot Y_f}$$

$$\text{Ln } \alpha_3 = \frac{1}{F} \sum_{f=1}^{F} \frac{P_{3f} \cdot X_{3f}}{P_{yf} \cdot Y_f}$$

where α_i, P_i, X_i, and Y are the same as defined earlier. $f = (1,\ldots,F)$ = number of ranching firms involved. This procedure assumes constant returns to scale and the production function as $Y_f = A\, X_1^{\alpha_1}\, X_2^{\alpha_2}\, X_3^{\alpha_3} e$ (that is, the error term is not associated with α_i).

The assumption of constant returns to scale and use of factor shares as a means of estimating the parameters of a production function is based on the exhaustion of the product in payments to factors involved according to their marginal productivity. This method does not apply where increasing returns to scale prevail, because total output is not enough to pay the factors their marginal physical products. Increasing returns to scale ensure the breakdown of marginal cost pricing, and thus rule out the existence of numerous firms. As long as there are many firms of all sizes in a market with no clear trend towards a single firm size, we can rule out the existence of increasing returns to scale.

Cost of jointly produced public goods

Objective three focuses the attention on the production of public goods which are jointly produced with livestock forage. The desired level of production is determined by society. The only thing the BLM, as a proprietor of the public goods enterprise, can identify and quantify, is the cost of the forage. Since the jointly produced public goods, some of which themselves are not quantifiable, are a function of the forage increase, the relevant question is the cost of a unit of forage increase. Let the cost of jointly produced public goods produced with one unit of additional forage be denoted by C_b.

$$C_b = \frac{\Sigma C}{\Sigma \Delta Q_1} = \frac{\Sigma C}{\Sigma \Delta AUM}$$

where C is the additional cost of livestock forage production including depreciation, interest, and maintenance of improvements and the management costs. But as pointed out earlier, the product forage itself is sold; and this sale reduces the average additional cost. Therefore, the real cost to the BLM as a proprietary agent attempting to increase $\tilde{B}_1$ will be $C_b - P_{Q1}$ where P_{Q1} is the effective price of an AUM, which is psid by the ranchers.

This leads us to the considerations for the entrepreneurs of the last resort, that is, society. From the viewpoint of society, any externality unpaid for, but accruing to one of its own members, should also be reckoned with. The value of this externality accruing to the ranchers grazing BLM lands per unit of livestock output is $\frac{\Delta A}{A} \cdot P_y$. The total value of the externality = $\frac{\Delta A}{A} \cdot P_y \cdot Y$, where Y is the total livestock weight produced on the rangelands covered by the allotment plans studied. The value of externality per unit of forage change is

$$S = \frac{\frac{\Delta A}{A} \cdot P_y \cdot Y}{\Sigma AUM}$$

From the viewpoint of BLM as an agent of the Sovereign, the real cost of the public goods increase $(\tilde{B}_1)$ is $C_b - P_{Q1} - S$. It is this cost against which the subjective estimate of the potential increase in $\tilde{B}_2$ should be compared when the BLM asks for public funds to increase nongrazing benefits.

CHAPTER IV

RESULTS AND DISCUSSION

The internal rate of return on BLM investments

All the grazing allotments studied included some improvement structures before the decisions were made to bring them under specialized grazing systems. Considerations of boundary demarcation, livestock distribution, better forage utilization, seeding, spraying or mere public relations were responsible for the fences, trails and water developments. But, once a decision was made to implement a specialized grazing system, each plan required an inventory of existing improvements and land features. Systems were then designed to use the existing structures and to provide additional improvement structures. In this study only the additional costs incurred for the specialized systems are considered an investment cost for the grazing systems. It is obvious that it would cost much more to implement a specialized grazing system on previously unimproved rangelands, but such entirely unimproved ranges are hard to find these days. So the plans studied are typical of the prevailing conditions and the design of systems is typical of contemporary specialized grazing systems. Full production capacity is not reached immediately upon installation of improvements for grazing systems. This is evidenced by the estimated schedule of forage production in Appendix C. These estimates were given by BLM officials based on their past experiences and design characteristics of the system involved. After the initial outlay of investment cost, the annual costs are constant, but annual returns are not. The nonuniform behavior of additional annual forage production due to specialized grazing systems is shown in Figure 1. The estimated increase in forage production is expected to level out after 1980. The forage increase is assumed to be uniform during the installment period.

The sale price of an AUM of forage is not uniform overtime. The BLM and Forest Service adopted a system of pricing of forage for public lands in 1967, based on a study of user charges released by the Bureau of the Budget in 1964. It was calculated that in 1966 prices, a fee of $1.23 per AUM would capture the full market value of forage after accounting for the users' costs difference on public and private lands. This figure was to be achieved in a period of 10 years starting in 1969 (Public Land Law Review Commission, 1970, p. 117, and Nielsen, 1971).

In 1967, the BLM raised the grazing fee to $0.44 from the previous three year rate of $.33 per AUM. A congressional moratorium on further fee hikes held the grazing fee at $.44 in 1970. The fee increase resumed in 1971 with the fee rising to $.64. It seems certain that the policy of raising fees to $1.23 per AUM on public grazing lands will be implemented, though the increases may not be uniform. For purposes of calculating the value of returns on investment in specialized grazing systems, it is assumed that the target year of 1978 will be met for restoring the parity of grazing fees to their desired level. In 1970 prices, this level is $1.36 per AUM. The assumed grazing fee schedule is given in Table 1. The cost of maintenance and administration of each plan is uniform overtime. The initial investments do not occur in a single year. Also the initial investments are repeated in the future to give all improvements an equal life span. The aggregate flow of gross returns

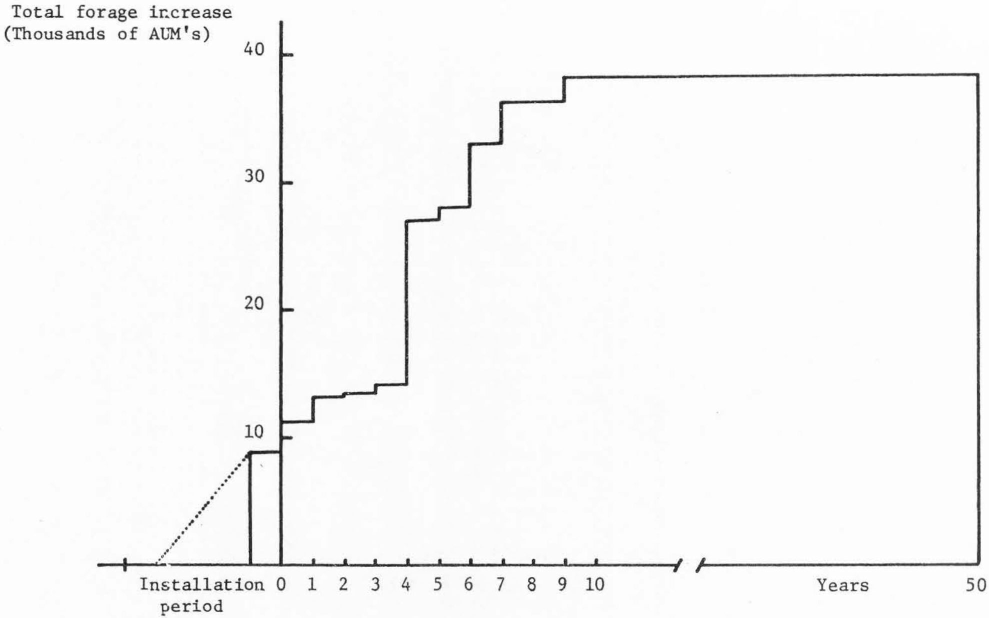

Figure 1. Patterns of forage increase from specialized grazing systems. (Solid line shows actual and estimated forage increase. The dotted line is assumed increase).

Table 1. Assumed grazing fee schedule in 1970 prices

Year	Grazing Fee. $
1970	0.44
1971	0.64
1972	0.74
1973	0.84
1974	0.94
1975	1.04
1976	1.14
1977	1.24
1978	1.36
1979 onwards	1.36

[a]This schedule for raising grazing fees is independent of grazing systems.

and costs is shown in Figure 2. Additional returns from the grazing systems are graphed above the horizontal axis and additional costs are shown below the horizontal axis.

The nonuniform returns and costs require a computational modification of the general formula of the internal rate of return given in Chapter III. The discount factor $(\frac{1 - (1 + i)^{-n}}{i})$ is applicable to the uniform costs of maintenance and administration. The modification of the formula below compounds the past and discounts the future returns and costs. The uniform and nonuniform changes are discounted separately. This modification still employs the criterion that the present value of gross returns equal the present value of costs.

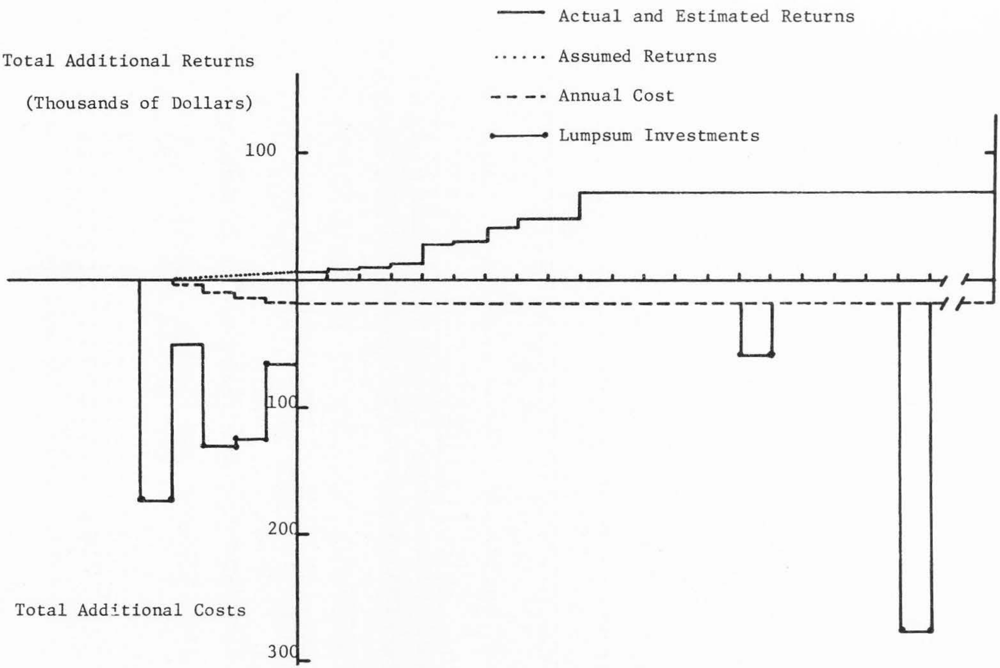

Figure 2. Aggregate flow of gross returns and costs from BLM investments over time.

That is, I = R where

$$I = I_0 + \sum_{j=1}^{S} (I_j + C_j)(1 + i)^{S-j} + \frac{C(1 - \frac{1}{(1+i)}^n)}{i} + \sum_{k=1}^{n} C_k \frac{1}{(1+i)}^k$$

$$R = R_n \frac{(1 - \frac{1}{(1+i)}^n - (1 - \frac{1}{(1+i)}^m)}{i} + \sum_{k=1}^{m} R_k \left(\frac{1}{(1+i)}^k \right) + \sum_{j=1}^{S} R_j (1+i)^{S-j}$$

The present value of cash flows = R - I where

I_0 = cost of investments in zero period (1970)

I_j = investment in the jth year of installment

S = installment period (5 years from 1966 to 1970)

n = number of years the returns are expected

C = annual cost for n years

C_j = annual cost in the jth year of installment

C_k = future investment needed in the kth year

R_n = gross returns which are uniformly received from m + 1 to n years

R_k = gross returns in the kth year

R_j = gross return in the jth year of installation

i = internal rate of return.

The general formula for the internal rate of return is known for its unwieldness. The above formulation is even more difficult to solve for i. A Frotran IV computer program was used to substitute various values of i into the equation until I = R was satisfied. A range of i from -300% to 30% was tested. The results should be viewed with this range of i values in mind. An interval of .001 was used for interactions.[1]

With the cost of investment, annual expenses and schedule of future returns given in Appendix C, the aggregate internal rate of return on BLM investments on the grazing allotments studied is 2.3687 percent. To check for the uniqueness of this result, the present values are graphed in Figure 3. Aggregate present values are a monotonically decreasing function of the discount rate (with the exception of zero, where the above equation is undefined).

The individual internal rates of return on the twenty-four allotments vary from -100 percent to 18.548 percent. These rates are reported in Table 2. These rates fall into three general categories: (1) $i > 0$; (2) $0 > i > -1$; and (3) $i \leq -1$.

The graphs of present values of cash flows from projects with positive internal rates of return resemble the graph of aggregate returns in Figure 3. The present value graph of positive absolute net returns, but negative internal rates of return is shown in Figure 4. The third category; viz., the projects with negative net returns, and thus with internal rates of return ≤ -1 may have more than one solution as shown in Figures 5 and 6. This figure is based on calculations using n as odd year. In this study n is 60 years, which is a common multiple of life spans of different improvements. This is an even number, and with $i < -1$; and, therefore, $(1 + i) < 0$, the term $(1 + i)^n$ gives contradictory results as compared to the results with n as an odd number. In the simple version

[1]This formulation is an nth degree polinomial. Hirshleifer (1959, p. 225) shows that the present value of cash flows can become zero as many times as the sign of receipt stream reverses; that is, for a period of n years, the present value can become zero n - 1 times. However, the range of the rates of discounts tested for this study is quite reasonable. Other solutions are rejected.

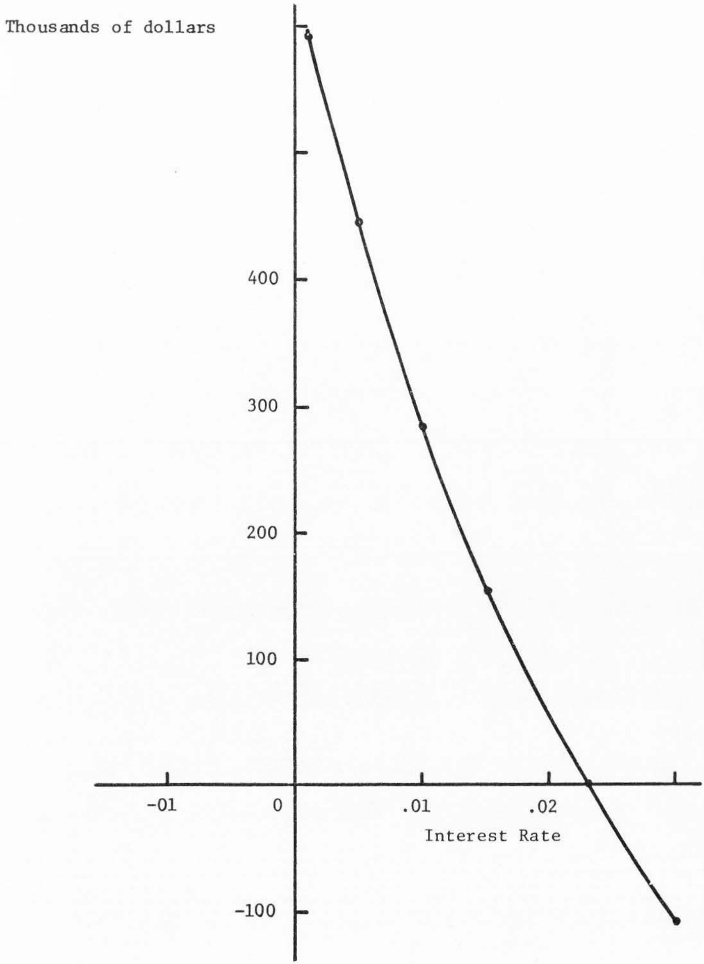

Figure 3. Present value of cash flows from BLM investments on 24 grazing allotments.

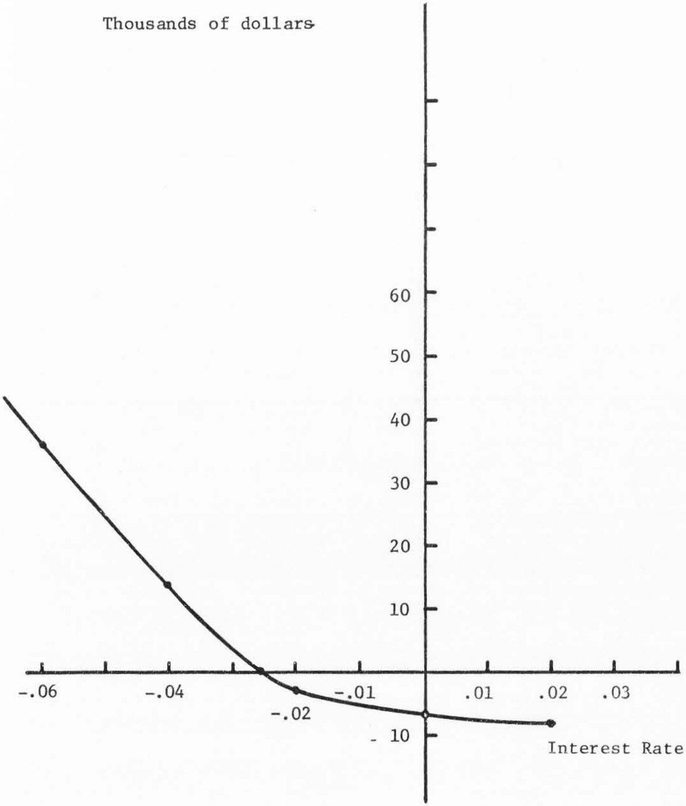

Figure 4. Present value of cash flows from an allotment with internal rate of return > -1 and < 0.0 (Spratling Allotment Nevada).

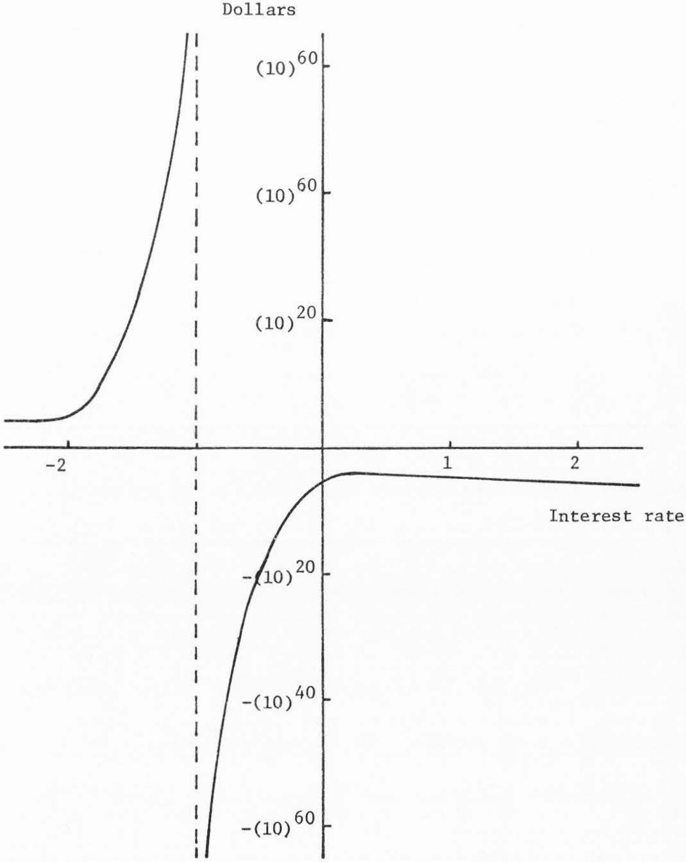

Figure 5. Present value of cash flows from BLM investment on Adorno Allotment when n is an odd year.

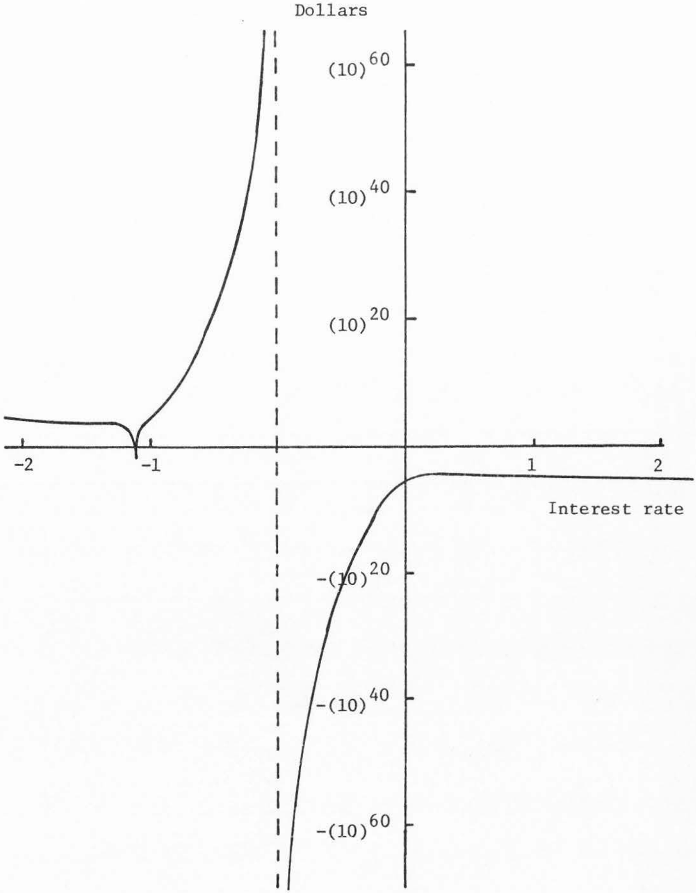

Figure 6. Present value of cash flows from BLM investment on Steptoe unit allotment when n is an odd year.

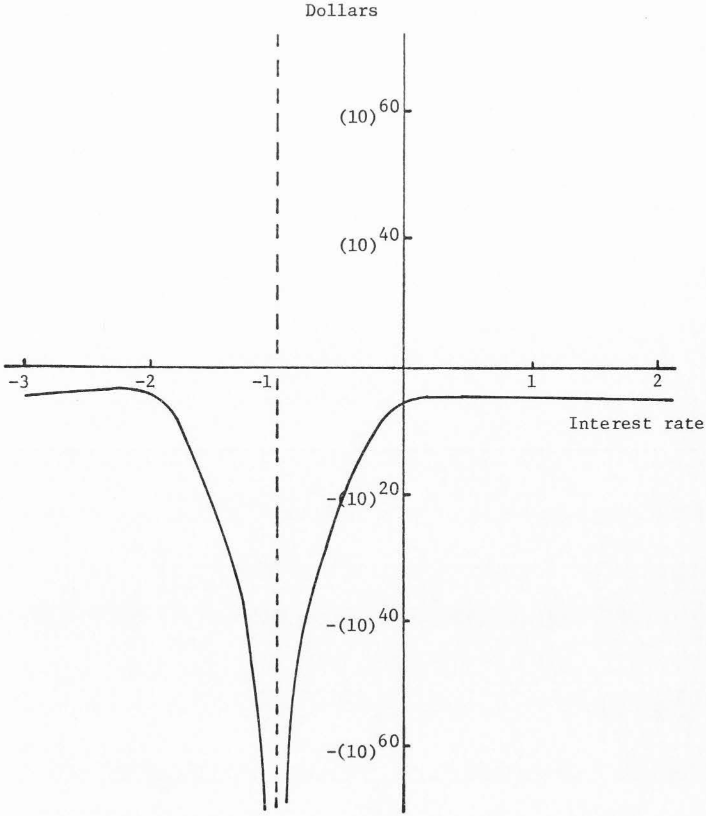

Figure 7. Present value of cash flows from BLM investment on Adorno Allotment when n is an even year.

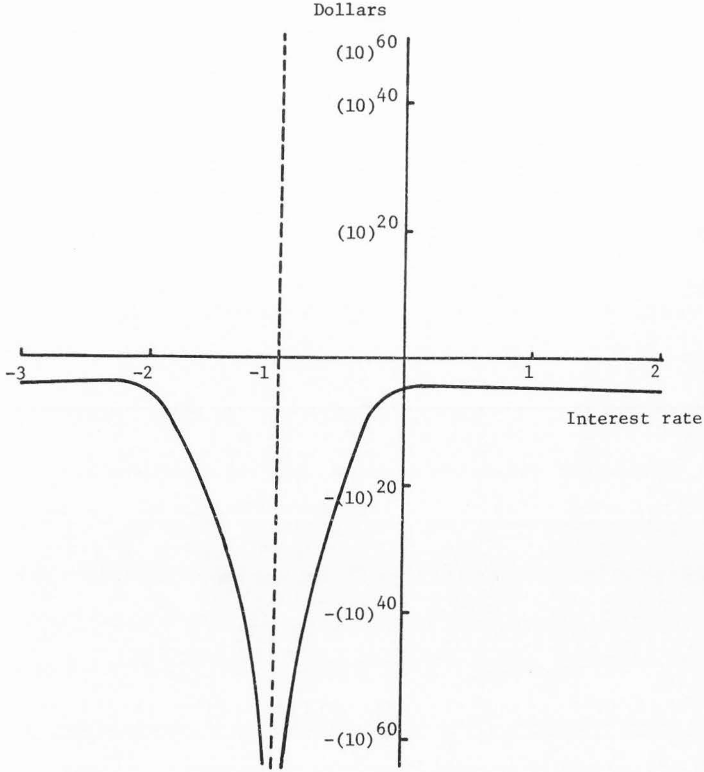

Figure 8. Present value of cash flows from BLM investment on Steptoe unit allotment when n is an even year.

Table 2. The internal rates of return on BLM investment on 24 grazing allotments in Idaho, Nevada and Utah (Appendix C)

Allotment Number	Internal Rate of Return	Allotment Number	Internal Rate of Return
1	≤ -1.0	13	≤ -1.0
2	.159812	14	.117613
3	.091533	15	≤ -1.0
4	.123513	16	- .018907
5	.075840	17	.007134
6	.182715	18	≤ -1.0
7	.140318	19	.185480
8	- .25605	20	≤ -1.0
9	- .180149	21	.022101
10	- .024033	22	≤ -1.0
11	.078854	23	≤ -1.0
12	- .050346	24	≤ -1.0

of net cash flows equal to $R(1 - \frac{1}{(1+i)}n)/i - I$, of Chapter III, there is no solution for the internal rate of return, because the net cash flows curve never reaches zero (Workman and Gardner, 1971).[2] For the modification employed in this study, there is no difference between the shapes of net cash flows curves using n as odd or even numbers for discount

[2]Workman and Gardner came to this conclusion while working with net returns which would satisfy the internal rate of return equation at different discount rates. They did not deal with the case of recurring investments.

rates greater than -1, as shown in Figures 4, 5, 6, and 7. Figures 4 and 5 show the present value of cash flows using n as odd number. Figures 6 and 7 are based on n as even number, but correspond to the returns and costs of Figures 4 and 5 respectively. To eliminate the inconsistency for discount rates less than -1, all time periods are treated as odd numbers.[3] Thus, Figures 5 and 6 represent the assumed behavior of the present value of the cash flows of projects with negative returns. These values of cash flows remain negative for discount rates > -1. They may or may not cross

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[3]The general formula of internal rate of return and

$$I = \frac{R(1 - \frac{1}{(1+i)^{n+1}})}{i} - \frac{R}{(1+i)^{n+1}}$$ are algebraically equivalent. This can be shown by setting the right hand side of both equations equal.

$$\frac{R(1 - \frac{1}{(1+i)^{n}})}{i} = \frac{R(1 - \frac{1}{(1+i)^{n}})}{i} - \frac{R}{(1+i)^{n+1}}.$$

Therefore, $\frac{R}{i} - \frac{R(1+i)^{n}}{i} = \frac{R}{i} - \frac{R(1+i)^{-n-1}}{i} - R(1+i)^{-n-1}$. By deducting $\frac{R}{i}$ and adding $\frac{R(1+i)^{-n}}{i}$ and $R(1+i)^{-n-1}$ on both sides, we get

$$R(1+i)^{-n-1} = \frac{R(1+i)^{-n} - R(1+i)^{-n-1}}{i} = \frac{R(1+i)^{-n-1}}{i}(1+i-1) = R(1+i)^{-n-1}.$$

Both sides are equal. This still leaves the conversion of the even number to an odd in the initial period up to year m and any later even year when recurring investment occurs. An approximation was used for the second term in the modified formula. The returns in the even years were assumed to have been received half in the year before and half in the year after.

the horizontal axis for discount rates < -1 at one or more points depending on the timing and amounts of costs incurred. The only conclusion which can be reached from these figures is that the investments with such cash flows curves have internal rates of returns less than or equal to -1.

The aggregate internal rate of return of 2.37 percent as well as the rates of return on individual allotments (Table 2) may be biased upwards because they are calculated from projected returns and actual costs. In each allotment there are further investments planned. It is quite possible that in spite of my cautioning the BLM officials to use the existing form and substance of the system in estimating future returns, consideration of some of the planned improvements might have entered into their estimates. Still a rate of 2.37 percent is low even compared to the public discount rate of 5.125 percent for 1970, announced by the Water Resources Council (1970, Document No. 70-9567).
Unless due consideration is given to the income distribution and public good aspects of grazing systems, it appears that society is paying a high cost for such investments in the form of foregoing more profitable alternatives.

The variation in the internal rates of return from individual allotments is very high. A glance at Table 2 shows that out of 24 allotment plans, 11 plans have positive rates, and 13 have negative returns. This is expected because of extreme diversity in topography, climate, vegetation and political conditions prevailing in different areas.

The enormous variability in the internal rates of return from investments on different allotments cannot be explained with the existing information. There are many factors which are responsible for large negative returns. Consideration other than efficiency of federal investments probably explains part of the variability. Such results were not expected, and no attempt was made to collect the information which would have answered these questions. These results demonstrate a need for collecting further information.

The list of 24 plans covered the available management plans in the three states where systems have been fully implemented. There are many more plans where specialized grazing systems are just now being implemented, which, of course, could not be included in this sample.

Changes in profits of private ranchers

The estimated coefficients of the livestock production functions using the factor shares method for both the years 1965 and 1970 are given in Table 3 below.

Table 3. Coefficients of the Cobb-Douglas production functions

	Coefficient	Standard error
1965		
	α_1 = .29317	(.261768)
	α_2 .55042	(.28983)
	α_3 = .25407	(.21958)
	$\Sigma\alpha_i$ = 1.09766	(.57574)
1970		
	α_1 = .26581	(.195159)
	α_2 = .48745	(.265452)
	α_3 = .20461	(.195468)
	$\Sigma\alpha_i$ = .957869	(.43683)

These results confirm the assumption of constant returns to scale. Coming from 26 observations, α_1 and α_3 significantly differ from zero at the 85 percent and α_2 at 95 percent significance level. α_i from 1970 data are not significantly different from those of 1965 (that is $\Delta\alpha_i$ is not significantly different from zero as shown in Table 4).

Table 4. Changes in α_i from 1965 to 1970

$\Delta\alpha_i$	Standard error
$\Delta\alpha_1$ = .02736	(.117048)
$\Delta\alpha_2$ = .06297	(.217319)
$\Delta\alpha_3$ = .04936	(.165574)

Using the α_i from 1965, the estimated $\frac{\Delta A}{A} = 0.11399$ ($\pm$ .169042). This technical change is neutral with respect to the inputs. The Hicksian definition of neutrality (Nadiri, 1970, p. 1143) requires that in the case of a production function (F) with inputs K and L, $\frac{\partial}{\partial_t} (\frac{\partial F}{\partial K} . K/\frac{\partial F}{\partial L} . L = 0$ with $\frac{K}{L}$ constant. In the three input model of this study and with a discrete change, this condition would be satisfied if

$$\Delta \left[\frac{\frac{\partial Y}{\partial X_1} \cdot X_1}{\frac{\partial Y}{\partial X_2} \cdot X_2} \right] = 0 \text{ with } \frac{X_1}{X_2} \text{ constant.}$$

Dividing the numerator and denominator by Y in the above expression, the necessary test for neutrality reduces to whether

$$\Delta \frac{\alpha_1}{\alpha_2} = 0 \text{ with } \frac{X_1}{X_2} \text{ held constant,}$$

and similarly whether

$$\Delta \frac{\alpha_2}{\alpha_3} = 0 \text{ with } \frac{X_2}{X_3} \text{ held constant.}$$

$\Delta \frac{\alpha_1}{\alpha_2} = (\frac{\alpha_1}{\alpha_2} - \frac{\alpha_1'}{\alpha_2'})$ when α_1 and α_2 are from the year 1965 and α_1' and α_2' are from 1970. Table 4 above shows that $\Delta\alpha_i$ is not significantly different from zero at the 99 percent confidence level (that is $\alpha_1 = \alpha_1'$ and $\alpha_2 = \alpha_2'$). Therefore,

$$\Delta \frac{\alpha_1}{\alpha_2} = 0, \ \Delta \frac{\alpha_2}{\alpha_3} = 0 \text{ and } \Delta \frac{\alpha_2}{\alpha_3} = 0.$$

With regard to the constancy of factor ratios, the technical change was measured by determining the ΔY at the base year levels of inputs.

$$\frac{X_1}{X_2}, \frac{X_2}{X_3}, \text{ and } \frac{X_1}{X_3}$$

were tested for both 1965 and 1970, and were found to be not significantly different between the two years. This means that the slopes of the two production functions in two years were tested along the same expansion path.

The neutrality of technical change might appear surprising in the face of all the talk about large capital outlays on grazing allotments. But if the source of the capital investments is kept in view, there is nothing surprising about these results. Fences and other capital outlays over and above the normal growth of ranching firms have been mostly carried out from federal funds, which are external to the production function.

The change in profit per unit of output is $\frac{\Delta\Pi}{Y} = \frac{\Delta A}{A} \cdot P_y$. The average price of yearling steers sold by the ranchers included in this study was \$.2763 per pound, which is equivalent to \$.32 in 1970 prices. Therefore, $\frac{\Delta\Pi}{Y} = .036477$.

This means that on the average, rancher's profits improved by 3.6 cents per pound of livestock produced. It seems the ranchers would not oppose the introduction of the specialized grazing systems on economic grounds. In fact, some ranchers have welcomed the systems, and a few requests to the BLM for the installation of specialized grazing systems have originated from the ranchers themselves. However, some skepticism also exists about the systems. After ruling out nonprofitability of the systems to the ranchers, it is likely that any opposition is merely resistance of a conservative section of the society to any radical change in their way of life, and the way they have done things in the past. Another plausable explanation could be fear of the dilution of already shaky semi-legal rights of grazing on public lands due to heavy BLM investments on public lands. Also, this study does not show the interim losses (during 1966-1969) in livestock weights, which the ranchers might have suffered due to sudden change in management practices.

Cost of public goods

From the nonuniform production of Q_1 as depicted in Figure 1, an equivalent uniform annual production of Q_1 comes to 36,290.4 AUM's. A comparable total annual cost (TC) is \$63,506.27. Annual figures for Q_1 and TC were calculated as below:

$$Q_1 = \left(\sum_{j=-s}^{n} \frac{Q_j}{(1+i)^j} \right) \left(\frac{i}{1 - (1+i)^n} \right)$$

$$\text{and } TC = \left(\sum_{j=-s}^{n} \frac{C_j}{(1+i)^j} \right) \left(\frac{i}{1-(1+i)^n} \right)$$

where $i = .05125$[1]

Q_j = the actual or estimated production of Q_1 in jth year

C_j = actual or estimated cost in jth year

S = period of installation (5 years)

The summation of present values for TC was calculated using the computational formulation employed on page 32. The term $\left(\frac{i}{1-(1+i)^n} \right)$ is the value of an annuity for a period of n years which is worth \$1 today. Therefore, the cost of the increase in Q_1, $(C_b) = \frac{\Delta TC}{\Delta Q_1} = \$1.7435$. From the grazing fee schedule of Table 1, the average fee the BLM is expected to receive is \$1.21 per AUM. This effective price (P_{Q1}) was calculated as

$$\left[\frac{(P_{Q1n})\ (i)}{(1+i)^m} + \sum_{j=1}^{m} P_{Q1j} \left(\frac{1}{(1+i)^j} \right) \right] (i)$$

where P_{Q1n} = \$1.36 = price of Q_1 in the nth year

i = .05125

P_{Q1j} = price of Q_1 in jth year as given in Table 1

m = number of years the price keeps rising.[2]

If production of forage is treated as the only activity for which investments in grazing systems were made, the effective grazing fee would have to be \$1.74 to break even. This means that grazing fees would have to be raised by <u>53¢</u> from the assumed effective price of <u>\$1.21</u>. Even if

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[1] This discount rate is declared by the Water Resources Council each year. It varies with the average yield of marketable long-term securities (15 years and over) of the United States Government for the previous five years. However, it is not equal to this average yield. The average yield determines only the direction of the change.

[2] $\frac{P_{Q1n}(i)}{(1+i)^m}$ is a simplified version of $\frac{P_{Q1n}}{i} - \frac{P_{Q1n}\left(1 - \frac{1}{(1+i)^m}\right)}{i}$.

grazing fees are raised to their full parity of \$1.36 <u>immediately</u> (which is unlikely), there would be a gap of 38¢ which would never be bridged. This is because \$1.36 is the fair market price of Q_1 after accounting for user costs on public lands. The ranchers cannot be expected to pay 38¢ over and above the prevailing market price. It seems, therefore, that as purely a forage raising device, the BLM investments in specialized grazing systems will never pay off. Even if the actual cost of an additional AUM was charged to the ranchers, it does not mean that each rancher should be charged equally. The study results are an average figure. To be realistic, each plan will have to be considered on its own merits. Separate consideration of grazing fees for each grazing system plan would require considerable additional effort on the part of the BLM.

Facing these results the BLM will probably put its role as a producer of jointly produced public goods ($\tilde{B}_1$) associated with Q_1 in the forefront. The net price per bundle of these public goods ($\tilde{B}_1$) is \$.53. Is this cheap or costly? We don't know, because the exact magnitude of $\tilde{B}_1$ is not known. Indications are that it is positive. Some of these goods can be measured in physical units. For example, acre feet of erosion reduction, pounds of litter increase, cubic feet reduction in peak flow of run off, etc. But, even these have not been exchanged in the market and as such do not serve as marketable units and their value in exchange cannot be determined. The determination of the "fairness" of the cost of a unit of $\tilde{B}_1$ is left to the political process. With increasing concern over the deterioration of the environment, a single positive effect of soil stability (of the many which the

BLM claims to have achieved in each case on the 695,024 acres of public land covered by this study) may be enough to cover this cost. The BLM's list of the positive nongrazing benefits falling into category $\tilde{B}_1$ includes wildlife habitat improvement, better watershed protection, closer rancher-BLM cooperation, enhancement of recreational values, improvement in aesthetic values, soil stability and stability in livestock operations.

Now turning to the BLM's role as an agent of the sovereign, the value of the externality $(\frac{\Delta\Pi}{Y})$ is positive; i.e., \$.03647. The total value of the externality is therefore (y) (.0364) = (3,785,860) (.0364) = \$138,070. Y is the estimated total livestock production[3] dependent on the public lands studied. With 36,290.4 AUM's of Q_1, the value of this externality per unit of Q_1 is S - \$3.80. This amount to obtaining a bundle $\tilde{B}_1$ at a net cost of \$1.74 - \$1.36 = \$.38 which improving the incomes of ranchers by \$3.80 for a net gain of \$3.80 - \$.38 = \$3.42 to the sovereign. It is up to the congress to decide whether this positive externality should be recognized as a goal of the federal investments in specialized grazing systems.

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[3]It was not possible to collect exact information on the actual pounds of livestock produced by all the ranchers involved. For estimating the total livestock production, advantage was taken of the fact that forage available from public lands is a limiting factor in most ranch operations. Production is dependent on the forage from public lands during the critical periods. It was found the maximum number of livestock grazed instead of the number of AUM's produced explained the livestock produced by the ranchers. This linear relationship determined by a least squares regression turned out to be Y = 260 N where N is the maximum number allowed to graze BLM lands. In this regression, the intercept was forced to zero to eliminate the dependence on number of firms involved. The F value for this relationship was 21.9 and R^2 = .47. The coefficient for AUM's was not significantly different from zero. An earlier regression with a constant term had the coefficient for AUM's significantly different from zero and R^2 of .69 but a regression with a constant term cannot be logically used for determination of Y at allotment levels.

CONCLUSION

The internal rate of return on the BLM grazing system investments over an area of approximately 695,024 acres in Idaho, Nevada and Utah is 2.37 percent. This is less than half the rate federal investments are expected to return (as measured by the federal government's cost of borrowing). More than half of the twenty four allotment plans have negative rates of return. Out of thirteen plans with negative rates of return only five have positive net returns and the rest have negative net returns.

Specialized grazing systems have improved the amount of aggregate profits of the private ranchers studied by 11.4 percent. Federal investment in specialized grazing systems may be justified if income distribution is considered a valid reason for such activities. If the stability and continuity of their operations is assured, ranchers may be able to pay increased grazing fees. In view of the fact that under public pressure the government has decided to withdraw rancher benefits in the form of grazing fees lower than market rates, income distribution appears to be poor grounds for justification of federal investment. Also, given the income benefits to ranch operations, ranchers themselves would undoubtedly want to invest in grazing systems on federal land. However, rancher investment is unlikely since the BLM is already discouraging private permanent improvements on public lands.

From the point of view of the BLM as a proprietory agent, the real cost of obtaining an increased bundle of non-grazing benefits produced jointly with an AUM of increased forage production is \$.53. A grazing fee of \$1.74 per AUM would be required for the BLM to break even on investments in grazing systems. This is in spite of the fact that large federal investments in necessary range improvements already existed before the implementation of the specialized grazing systems. It appears the investments in grazing systems on unimproved ranges are not justifiable in terms of direct returns to the BLM.

If the externality to the ranching segment of society is internalized, specialized grazing system benefits discounted at the public discount rate more than outweigh the costs. Many questions are left unanswered such as quantifying and placing a dollar value on rangeland benefits claimed by the federal agencies.

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APPENDIXES

Appendix A

The Specialized Grazing Systems

Grazing systems are planned programs of livestock management to accomplish a desired result. They are designed to provide for the requirements of soil, plants and livestock. Soil is a complex body with varied physical, chemical and biological characteristics. Its condition is reflected in its products; viz., plants, water, etc. The simplest of all its characteristics, the moisture content, can make a tremendous difference in the results of livestock trampling. Livestock need feed and water to put on weight and produce calves. Plants hold the crucial central position in this three way relationship. Primary plant growth takes place from stored carbohydrates ($C_6H_{12}O_6$). The level of stored carbohydrates during the growing season depends on the uses of carbohydrates in respiration and growth and the replenishment of the storage through photosynthesis. The process of photosynthesis uses carbon dioxide and water to produce carbohydrate and oxygen in the presence of sun light. (Meyer, Anderson and Bourning, 1960, p. 133).

$$6\ CO_2 + 6\ H_2O \xrightarrow{\text{673 kg-cal. of radiant energy}} C_6H_{12}O_6 + 6O_2$$

The factors affecting the process of photosynthesis are presence of CO_2, leaf surface, light intensity, water supply, temperature, soil nutrients and physiological efficiency of plants. Of these factors leaf surface is the direct food of the livestock. Water supply, temperature and soil nutrients are affected indirectly.

Carbohydrates are generally stored in underground organs such as roots, tubers, rhizomes, stolons; in crown or stem leaves of herbacious species and also in twigs of woody plants. These reserves are used for initial growth in spring, for rapid growth during the year and for secondary growth in the fall. The plants fall back upon these reserves for new photosynthetic tissue when overgrazed. The reserves are lowest when rapid growth occurs in spring. The relationship between herbage yield and carbohydrate reserves is shown in Figure 1 below.[1]

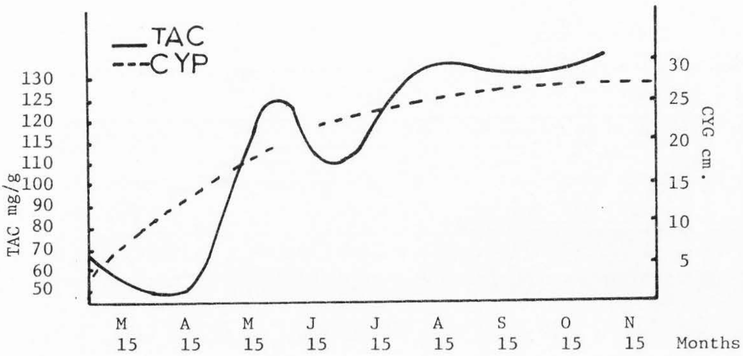

Figure 9. Relationship between average total available carbohydrates (TAC) in roots and crowns of squirreltail and average length of current year's growth (CYG).

Livestock relish new succulent growth. The protein content and vitamins are also high in the early stages of growth. But carbohydrate reserves are generally the lowest at this stage. "It is believed that a plant that prolongs replenishment of the reserves following initial growth is more susceptible to grazing stress during the growing period than a

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[1] This follows Patric I. Coyne (1969).

plant that replenishes its reserves rapidly following initial growth" (Cook, 1966). p. 8). Likewise, a plant growing rapidly in the early stages is more susceptible to early grazing than a plant growing slowly in early stages.

Since vegetation of each rangeland is composed of different species of grasses, forbs and woody plants and since each species has different growth patterns and carbohydrate and nutrient cycles, it is impossible to provide for the requirements of all species as well as the livestock and soil at the same time. Various grazing systems attempt to use the fragmented information regarding each element of the ecosystem and provide for the requirement of at least key species. The advanced grazing systems provide plants a chance for attaining vigor, seed maturity, and regeneration after certain intervals of time on one part of the range while other parts are being grazed. This is illustrated by Figure 2 put up by the BLM offices in Nevada.

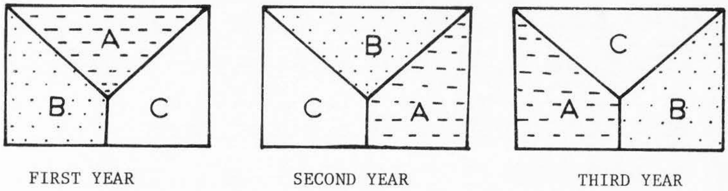
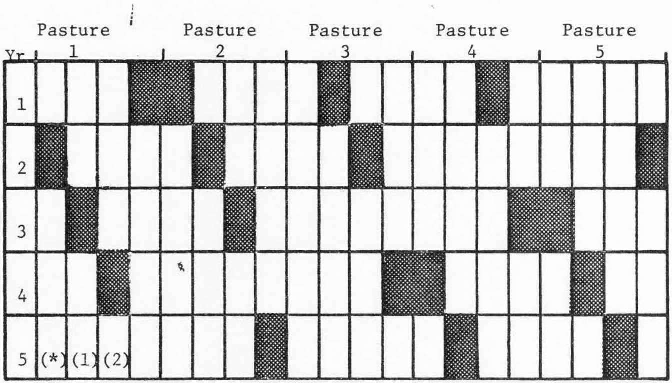


Figure 10. A three pasture rest rotation system.

A. <u>Full Grazing</u>: Provides maximum forage for livestock. Improves plant composition by using all forage plants.

B. Grazing after seed ripens: Ungrazed plants gain vigor and produce seed more readily during the growing season. When the seed is ripe it is knocked to ground early, trampled in and planted by livestock. Grazing after seed ripens ensures establishment of new seedlings.

C. Rest during entire season: The rest pasture is the one grazed when seed was ripe the year before. Plants are protected from all livestock grazing during seedling establishment, and older plants gain vigor. This rest is essential for a healthy rangeland. Reproduced from the BLM manual, Figures 3 and 4 are examples of a five pasture rest rotation system and a five pasture year long, seasoned rotation system (BLM, 1968. p. 3-8). Figures 5, 6, and 8 are examples of grazing systems from allotments in Utah, Nevada and Idaho. These systems are based on the assumption that plants can recover from even severe use by a periodic rest.



(*) = 3 month period, (1) = cool season grass growth period.
(2) = warm season grass growth period.

Graze Rest

Figure 11: Five pasture grazing system - year-long grazing subject to severe drought periods. Warm season and cool season grasses both important on allotment.

Yr	Pasture 1	Pasture 2	Pasture 3	Pasture 4	Pasture 5
1	G	RV	RS	RR	RR
2	RV	RS	RR	RR	G
3	RS	RR	RR	G	RV
4	RR	RR	G	RV	RS
5	RR	G	RV	RS	RR

G = Graze until direct utilization, RV = Rest for vigor
RS = Rest until seed ripe, then graze, RP = Rest for Preproduction

Figure 12. Five pasture system where key species require one season of rest for restoration of vigor and two seasons for seeding establishments.

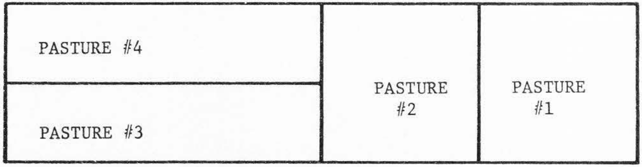
Yr				
1	Graze until flowering 4/1 to 6/15	Rest until seed ripe, then graze 9/1 to 10/31	Rest	Rest until flowering, then graze 6/16 to 8/30.
2	Rest until seed ripe, then graze 9/1 to 10/31	Rest	Rest until flowering, then graze 6/16 to 8/30	Graze until flowering 4/1 to 6/15
3	Rest	Rest until flowering, then graze 6/16 to 8/30	Graze until flowering 4/1 to 6/15	Rest until seed ripe, then graze 9/1 to 10/31
4	Rest until flowering, then graze 6/16 to 8/30	Graze until flowering 4/1 to 6/15	Rest until seed ripe, graze 9/1 to 10/31	Rest

Figure 13. Four pasture rest-rotation system included in Smith Cottonwood Allotment Management Plan, Elko, Nevada.

TREATMENTS		FIELDS RECEIVING TREATMENT YR.1	YR.2	YR.3	YR.4	YR.5
A	GRAZE	NW	SW	MID	NE	SE
B	REST FOR VIGOR	SE	NW	SW	MID	NE
C	REST FOR SEED RIPE / GRAZE	NE	SE	NW	SW	MID
D	REST FOR SEEDING ESTABLISHMENT	MID	NE	SE	NW	SW
E	REST FOR SEEDING ESTABLISHMENT / GRAZE	SW	MID	NE	SE	NW

4/16 5/1 6/1 7/1 8/1 9/1 9/30

Figure 14. Five pastures (NW, SE, NE, MID, SW) rest rotation grazing system implemented on Richfield Allotment, Shoshone, Idaho. Grazing season is from 4/16 to 9/30



PASTURE	FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR
1	S	LS	F	R
2	LS	F	R	S
3	F	R	S	LS
4	R	S	LS	F

S = May 1 to May 25
LS = May 26 to June 20
F = November 1 to December 31
R = Rest

Figure 15. Rest rotation grazing system implemented on Yost Pastures, Salt Lake District, Utah.

Appendix B

Method of Data Collection and Compilation

Questionnaires were prepared to collect information on costs and production from both ranchers and the Bureau of Land Management District Managers. These questionnaires were developed after a preliminary field trip to the Fillmore District. Bureau of Land Management District offices at Fillmore, Salt Lake City and Brigham City in Utah; Boise, Idaho Falls, Shoshone and Burley in Idaho; and Ely, Elko and Winnemucca in Nevada were contacted for information on grazing systems.

Each of these offices were asked for all the management plans prescribing specialized grazing systems. Plans covering only cattle ranges were asked for. Only the plans implemented between 1965 and 1970 were selected. Then the Bureau of Land Management offices were asked to supply the costs of improvement projects put in for the systems along with the year of completion and maintenance responsibilities. The Resource Chief and Area Managers of each District jointly estimated the costs of development of the plan, maintenance costs, life expectations on projects and also the expected further increases in forage production from each plan area as a result of new grazing systems. A photocopy of each plan selected was obtained. The costs of projects and figures on actual production were obtained from the BLM records. Twenty-four allotments were covered.

Addresses of the ranchers operating in the area were acquired from the Bureau offices. The operators were contacted by telephone to arrange appointments after explaining the nature of information sought and also after assuring them that individual names and information would not be made available to any other agency. Personal interviews were then held. Ranchers invariably needed elaborate explanations of some items of the questionnaire. Both records and estimates were used by ranchers to answer the questions. Only the ranchers who had owned the present ranches for at least the last six years were interviewed. In the case of individual allotments, the sample of owners was 100 percent. But in joint allotments, the owners interviewed varied from 3 to 50 percent of the permittees operating in an allotment.

Compilation. All the costs and returns were converted into 1970 prices using the wholesale price indexes of all commodities[1]. The value of ranchers inventories of rangeland privately owned, BLM, State land and Forest Service permits, mother herds, horses, bulls, fences, buildings and equipment were included in fixed capital costs. The annual costs on supplemental feeds, hay, salt, repair of fences, watering facilities, buildings, BLM, Forest Service and state grazing fees, private rentals of pastures, veterinarian charges, value of the aftermath and all other miscellaneous cash costs other than labor were included in the working capital. All the cost of labor, owned and hired was added up as labor costs. The ranching operation was separated from grain and hay raising activities of the ranchers. This explains the inclusion of the cost of feeds, hay and aftermath of grain and hay fields in the working capital

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[1] Index of wholesale prices up to 1969 was taken from statistical abstracts for the U.S., 1970, and that for 1970 was taken from Survey of Current Business. April, 1971.

because the rancher could have sold these for cash if they had not been used for his own operations.

The livestock weights produced were converted to yearling steer weights by dividing the gross revenues from sale of all categories of livestock by the average price of yearling steers. The average price of yearling steers was determined by $\frac{\Sigma P_{sf} \cdot Y_{sf}}{\Sigma Y_{sf}}$ where P_{sf} is the price per pound of yearling steers received by the fth firm and Y_{sf} is the pounds of live weight of yearling steers sold by the fth firm.

Appendix C

Changes in Production and Costs of the BLM

Table 5. Summary of Forage Production Changes on BLM Allotments

ALLOTMENT	CLASS I PERMIT	Δ PRODUCTION (AUM) 1965	1970	EXPECTED	IN YEAR	Δ COST ($) INVESTMENTS[a]	ANNUAL
IDAHO							
Pleasant View	17,438	16,551	15,034	17,438	1980	156,076.92	4,330.0
Kerr	627	1,155	2,596	3,330	1971	10,070	300.0
Goose Creek	9,918	4,539	5,447	9,918	1977	21,116.95	800.0
Bute Canal	1,528	658	924	1,526	1972	8,247.46	-400.0
Valley	988	483	655	755	1974	2,510.40	55.0
Richfield	3,360	1,257	1,757	5,000	1978	7,972	-60.0
Shoshone	12,702	10,196	10,234	20,000	1975	36,721	-250.0
NEVADA							
Spratling	1,014	990	1,205	1,570	1980	750	500.0
Horace Smith	2,100	2,100	2,079	2,520	1971	17,896.85	500.0
Jordan Valley Meadow	19,233	10,294	10,926	13,110	1975	98,097.78	500.0
Willow Creek		814	1,342	1,476	1974	2,450	500.0
Long Canyon	1,675	1,569	1,871	2,432	1977	29,916	750.0
Andorno	873	995	1,269	1,326	1974	18,890.55	1,000.0
Flatcreek	4,550	2,425	3,012	4,217	1972	6,659	750.0
Buffalo	338	296	345	379	1974	15,740.70	750.0
Heusser Mountain	1,933	1,416	1,784	1,933	1973	13,092.87	760.0
Steptoe Unit	4,471	2,779	4,066	4,446	1976	19,411.78	1,235.0
Smith Creek	4,202	5,386	5,386	5,689	1974	8,188.40	1,645.0
Cold Creek	9,471	9,471	12,799	12,799	1970	9,542.11	1,072.0
Duck Creek	2,471	1,359	1,412	2,471	1975	10,063.78	1,630.0
UTAH							
Yost Pastures		800	1,206	1,206	1970	4,537.33	260.0
Finlinson	283	238	60	100	1975	550.00	200.0
Southtract Cattle		2,340	2,475	2,475	1970	3,632.56	950.0
Carter Unit	2,738	743	1,132	1,132	1970	8,800.40	250.0

[a]These are total costs of investment incurred in the installation period (1970 prices).

Appendix D

Summary of Costs and Returns of Ranchers

Table 6. Summary of Value of Fixed Capital (1965) Dollars

	RANGE LAND	B.L.M. PERMIT	F.S. PERMIT	MOTHER HERD	HORSES	BULLS	FENCES	BUILD-INGS	EQUIP MENT
1	38,000	49,500	0.0	58,800	3,000	6,000	0.0	10,000	6,200
2	30,000	105,000	59,500	55,500	8,000	20,000	8,000	5,000	7,000
3	47,100	37,035	11,250	126,000	4,000	9,800	0.0	2,900	9,000
4	36,000	18,905	5,225	60,000	1,500	4,500	2,500	5,000	5,700
5	12,810	22,000	2,000	25,900	1,400	4,000	0.0	800	2.070
6	200,000	119,016	6,534	175,000	9,000	23,600	0.0	14,500	5,000
7	76,000	28,800	0.0	100,000	900	7,500	0.0	20,000	5,200
8	56,000	37,500	0.0	35,000	1,200	3,250	0.0	5,000	3,800
9	85,400	59,400	0.0	25,000	3,000	7,500	0.0	5,000	5,955
10	53,910	36,200	0.0	112,870	3,125	19,200	2,662	960	9,645
11	37,000	18,700	1,000	29,920	1,000	1,750	2,790	2,500	14,750
12	20,550	18,300	10,125	40,960	800	5,850	0.0	500	3,830
13	6,400	5,300	0.0	7,950	1,000	848	0.0	2,500	2,720
14	6,000	10,000	0.0	22,500	1,400	1,500	960	1,000	652
15	42,658	20,450	18,100	45,000	800	3,000	0.0	8,000	9,940
16	180,000	20,000	14,200	60,000	500	3,000	0.0	5,000	1,050
17	350,000	9,405	0.0	90,000	1,500	9,000	0.0	0.0	8,500
18	0.0	10,100	0.0	40,000	650	1,200	100	6,000	9,900
19	0.0	10,080	0.0	21,600	500	2,000	0.0	2,120	2,081
20	30,000	25,080	0.0	37,125	950	3,825	0.0	2,100	2,830
21	7,900	7,800	0.0	15,750	800	1,800	0.0	500	8,800
22	17,250	17,250	0.0	15,000	1,200	1,200	0.0	3,000	8,900
23	0.0	1,000	0.0	16,800	500	500	0.0	1,250	4,533
24	11,040	10,100	0.0	15,150	800	1,500	0.0	0.0	2,141
25	0.0	2,020	0.0	16,425	125	1,200	165	400	2,300
26	0.0	1,750	0.0	5,600	200	500	300	1,500	1,100

Table 7. Summary of Variable Costs (1965) Dollars

	FEED[a]	FENCE REPAIRS	OTHER REPAIRS	BLM FEES	FS FEES & STATE	RENTAL PRIVATE	FUEL	VET	AFTER-MATH
1	16,010	120	550	297	0.0	0.0	675	550	5,480
2	7,836	0.0	630	273.70	0.0	0.0	600	500	4,800
3	16,015	400	1,100	1,267	240	0.0	1,000	36	2,000
4	16,184	500	150	387.30	109	3,000	800	250	200
5	5,401	90	100	494.70	86	0.0	140	20	1,110
6	16,502.93	1,000	2,000	2,909.8	382.8	0.0	2,400	250	201.6
7	1,380	444	600	1,061	0.0	0.0	225	50	3,500
8	2,825	200	200	217.5	0.0	0.0	300	100	0.0
9	3,527.5	0.0	0.0	0.0	0.0	1	960	180	800
10	22,300	0.0	300	798	0.0	1,225	2,400	500	3,500
11	5,584	550	100	305.4	147.5	35	700	25	880
12	6,315.2	1,000	100	354	238.68	54.74	890	176	3,584
13	2,445.9	0.0	0.0	58.2	0.0	0.0	500	106	576.5
14	4,121	0.0	0.0	48.3	0.0	900	600	150	300
15	33,580	200	150	101.7	351.16	48	574	75	5,000
16	9,565	100	40	181.59	370.0	54	242.5	500	1,800
17	15,370	500	500	381.15	56.6	0.0	1,665	200	2,000
18	11,575	412	300	245.7	0.0	0.0	300	50	900
19	5,662.2	220	350	159	0.0	0.0	320	42.5	1,512
20	8,225	573	150	201.30	0.0	0.0	200	188	1,055
21	4,025	266	0.0	130.24	0.0	0.0	516	100	630
22	9,380	498	0.0	83.10	0.0	0.0	600	100	860
23	10,009	0.0	0.0	36.30	0.0	665	224	250	1,008
24	4,658	110.8	0.0	145.5	0.0	0.0	720	25.25	840.84
25	8,856	200	50	69.3	0.0	1,314.0	400	40	235
26	2,930	50	20	50.1	0.0	150	30	20	150

[a]Feed includes hay, grain, salt, maintenance of bulls and horses not sent on the public ranges.

Table 8. Summary of Value of Fixed Capital (1970) Dollars[b]

	RANGE LAND	BLM PERMIT	F.SERVICE PERMIT	MOTHER HERD	HORSES	BULLS	FENCES[c]	BUILD-INGS	EQUIP-MENT
1	148,000	60,250	0.0	28,500	3,600	11,050	0.0	17,000	4,800
2	30,000	200,000	115,000	105,000	8,000	11,500	6,000	10,000	9,000
3	55,000	59,310	11,250	180,000	4,500	10,800	8,500	56,000	20,000
4	45,000	24,111	5,225	151,250	1,500	10,800	1,100	5,000	12,000
5	17,080	25,000	2,000	40,000	2,400	5,400	0.0	800	1,560
6	325,000	148,770	9,990	142,360	15,000	28,350	0.0	9,500	12,800
7	45,500	108,000	26,125	286,000	1,750	20,000	2,000	20,000	11,650
8	70,000	42,500	0.0	40,000	2,100	4,950	1,500	5,000	2,650
9	190,400	110,000	0.0	157,500	4,000	8,250	0.0	7,000	9,000
10	60,900	54,300	0.0	91,710	3,750	12,350	0.0	2,700	6,960
11	39,750	210,375	1,380	37,400	1,000	3,200	170	3,500	17,700
12	52,800	21,960	10,530	46,025	1,000	6,500	2,000	1,000	4,195
13	14,600	15,500	0.0	37,200	1,000	2,480	0.0	1,700	3,425
14	10,000	10,500	0.0	32,500	1,400	4,200	700	3,000	1,105
15	58,023	30,650	30,000	72,000	1,100	4,500	0.0	8,000	9,940
16	210,000	27,000	22,100	115,000	400	3,000	0.0	5,000	6,500
17	374,400	22,130	0.0	174.250	1,500	29,000	0.0	0.0	4,500
18	0.0	10,100	0.0	53,500	1,200	1,300	1,100	6,000	4,875
19	0.0	14,400	0.0	18,800	400	2,000	0.0	2,500	1,579
20	60,000	24,750	0.0	53,400	2,000	5,500	0.0	3,300	2,583
21	8,390	8,580	0.0	21,500	3,200	2,000	0.0	500	11,300
22	17,250	17,250	0.0	40,000	1,400	6,600	0.0	5,100	6,700
23	0.0	1,120	0.0	6,800	250	800	0.0	1,200	1,443
24	4,300	4,140	0.0	39,000	1,000	1,200	0.0	0.0	1,037
25	0.0	3,520	0.0	22,500	125	1,500	300	2,000	500
26	0.0	8,000	0.0	10,000	200	600	0.0	1,500	266

[b]The serial numbers here bear no relationship to serial numbers of grazing allotments. Therefore no attempt should be made ot identify the cost and production data of specific individual ranchers. Also the ranches studied do not cover all the allotment plans studied for determining the internal rate of return.

[c]These are the values of fences not included in permit value and value of fences on owned range and buildings.

Table 9. Summary of Variable Costs (1970) Dollars

	FEED	FENCE REPAIR	OTHER REPAIR	BLM FEES	F.S. STATE FEES	RENTALS PRIVATE PASTURES	FUEL	VET	AFTER-MATH
1	23,020	230	750	530	0.0	1,520	950	940	5,480
2	22,850	1,300	1,500	1,085	424.20	0.0	900	500	4,800
3	28,662	4,100	3,000	402	0.0	0.0	2,400	375	3,500
4	30,524	550	1,200	784.54	185	4,000	1,600	700	2,000
5	6,905	80	200	801.68	114	0.0	200	100	2,520
6	11,928.74	1,000	2,000	6,022.16	587.4	0.0	3,000	250	162.48
7	3,300	700	1,300	1,618.32	100	0.0	258	1,200	4,500
8	4,490	100	100	374.0	0.0	0.0	375	200	150
9	13,653.50	360	600	751	0.0	1	2,400	700	1,350
10	9,510	0.0	1,000	1,046.76	0.0	1,475	2,400	575	4,372
11	8,240	650	100	552.2	222	0.0	875	35	880
12	6,350	400	0.0	532.4	357.69	0.0	905	48.76	4,000
13	6,000.15	100	0.0	269	0.0	0.0	300	248	1,302
14	20,248.40	0.0	0.0	105.6	0.0	1,500	700	400	6,300
15	48,680	200	0.0	238.92	582.16	0.0	600	150	5,000
16	13,005	130	145	381.92	545	0.0	253	700	2,400
17	36,375	0.0	0.0	942.48	57.6	0.0	975	1,700	450
18	10,086	912	600	279.18	0.0	0.0	400	50	1,020
19	7,955	296.50	300	233.64	300	0.0	600	20	1,300
20	11,870	600	180	273.24	0.0	0.0	200	344	1,350
21	4,015.80	257.35	0.0	107.70	0.0	0.0	531	150	860
22	22,564	855	0.0	247.28	0.0	0.0	1,200	600	1,200
23	6,617.32	120	0.0	101.52	0.0	450	325	240	1,120
24	7,384	0.0	50	174.24	0.0	0.0	249.4	200	900
25	10,886	27	300	154	0.0	2,400	450	92	260
26	4,970	65	0.0	88	0.0	210	30	60	250

Table 10. Labor Costs (Dollars)

1965	1970
5,602.61	5,876.27
11,565	12,050
11,139	12,120
4,772	6,344.75
4,865	7,350
14,487	22,980
1,400	6,989.5
5,215	5,982.5
9,961.5	11,223
14,426.25	17,655
5,999.0	16,555
8,184	9,090
1,297.5	1,870
8,297.5	13,500
8,180	6,960
9,450	10,120
3,290	5,680
12,477	13,640
3,507	5,294
2,710	4,540
4,138	6,200
6,960	8,980
4,023.7	2,200
3,975	4,688
2,980	4,920
716	2,820

Table 11. Value of Sales of Livestock (Dollars)

1965	1970
29,370.40	59,618.78
24,051.00	46,016.50
49,902.00	25,530.00
34,861.5	55,062.50
19,205.12	25,268.08
104,582.00	350,468.65
41,400.00	102,500.00
12,825.00	21,397.00
20,250.00	61,277.20
44,845.98	67,693.99
16,308.75	27,291.25
19,499.6	21,565.26
9,354.5	26,903.49
12,750.00	30,764.00
50,781.00	75,714.00
36,939.00	61,119.60
55,040.00	126,809.00
14,000.00	15,890.00
14,726.6	15,042.00
15,862.0	20,880.49
8,470.70	15,289.04
9,350.0	35,971.86
10,562.5	12,055.40
17,106.0	17,740.92
14,102.0	19,714.25
3,840.0	6,200.00

Appendix E

Questionnaire on Cost of Production of Livestock by Ranchers Using Public Lands Administered by Bureau of Land Management

Year______

A. Fixed capital

1. Rangeland owned acres____, at $______ = $______ T/E*______

2. BLM Permit A.U.s____, at $______ = $______ T/E ______

3. Forest Service No. _____, at $______ = $______ T/E ______

4. Mother Herd No. _____, at $______ = $______ T/E______

5. Horses No. _____, at $______ = $______ T/E ______

6. Bulls No. _____, at $______ = $______ T/E ______

7. Buildings: i-____, $____, expected life = ___years T/E______

   ii-____, $____, expected life = ___years T/E______

   iii-____, $____, expected life = ___years T/E______

8. Fences: BLM land____$____, expected life = ___years T/E______

   on own land____$____, expected life = ___years T/E______

9. Watering: BLM land__$____, expected life = ___years T/E______
   facilities
   on own land__$____, expected life = ___years T/E______

10. Equipment

	Item	No.	Make Year	Original price paid	Present value $ estimate	Life Exp. Est.	% age use for L.S. operation
i							
ii							

*T = Information from actual transaction
E = Estimated present value by the rancher

10. Equipment (cont)

	Item	No.	Make Year	Original price paid	Present value $ estimate	Life Exp. Est.	% age use for L.S. operation
iii							
iv							
v							

B. Working Capital (Cash costs other than labor).

1. Feed

   i. Hay $________

   ii. Grain $________

   iii. Silage $________

   iv. $________

   v. $________

2. Salt $________

3. Fence repair material $________

4. Watering facilities repair material $________

5. BLM grazing fees $________

6. Forest Service G. fees $________

7. State land lease fees $________

8. Private pasture rentals $________

9. Fuel for machinery $________

   a. $________

   b. $________

   c. $________

10. Veterinary expenses $________

11. Pasturing on aftermath of hay and grain $________

12. Repair of equipment $________

13. Repair of buildings $________

14. Feeding bulls and horses not included in (1) above $________

15. Any other

C. Labor

	Self	Hired	
1. General care taking and winter feeding =			man days.
2. Driving/trucking up to the range =			man days.
3. Feeding and salting on rangeland =			man days.
4. Moving livestock between pastures =			man days.
5. Rounding up and driving or trucking back =			man days.
6. Fence and water facilities repair =			man days.
7. Branding =			man days
8. Any other =			man days

D. Prices of factors

1. Borrowed fixed capital: Amount $____, Source____interest rate___

2. Owned fixed capital: Amount $____, Alternate Investment______

   Opportunity cost ________

3. Borrowed cash costs: Amount$_____, Source____interest rate___

4. Cash on hand: Alternate investment in mind___Opportunity cost__

5. Labor wage rate: a) Self$____ b) Hired$_____ per man day.

6. Fuel price a) ______

   b) ______

   c) ______

E. Product and Product Prices

	Item	No. Produced	No. Sold	Weight	Price	Total $
i	Steer calves					
ii	Heifer calves					
iii	Cows					
iv	Yrg steers					
v	Yrg heifers					
vi	Bulls					

General description of the operation:

Appendix F

Questionnaire on BLM Cost-Benefit Data on Implementation of Grazing Systems

District________________________Allotment____________________________

A. Cost on development of the system

(Additional information

B. Cost of Implementing the System

1. Selling of the project (manhours on meetings) $______________
2. Fencing Exp. life________ $______________
3. Water development Exp. life________ $______________
4. Trail building Exp. life________ $______________
5. Seeding spray Exp. life________ $______________
6. Administration costs Exp. life________ $______________
7. Repairs $______________
8. Any other $______________

Benefits

1. A.U.M.'s produced before the system = ____________________________
2. A.U.M.'s produced after the system = ____________________________
3. Expected A.U.M.'s to be maintained = ______starting in year_______
4. Other benefits
   i. __________________________
   ii. __________________________
   iii. __________________________

Remarks

Appendix G

Definitions of Technical Terms[1]

ADJUDICATION. The allocation of rights following a hearing of conflicting claims either by a court or a hearing board. May refer to grazing, water or any other rights. Also, the apportionment of grazing use on public range among eligible applicants.

AFTERMATH. Regrowth of range or artificial pasture forage after grazing or harvesting.

ALLOTMENT. An area designated for the use of a prescribed number of cattle or sheep, or by common use of both under one plan of management.

ANIMAL UNIT MONTH. The amount of feed or forage required by an animal unit for one month. Not synonymous with animal month.

COMMENSURABILITY. Capacity of a permitee's base ranch property to support permitted livestock during the period such livestock are off public land.

CONTINUOUS GRAZING. Allowing domestic livestock to graze a specific area throughout the grazing season. The term is not necessarily synonymous with yearlong grazing.

DEFERRED GRAZING. Discontinuance of grazing by livestock on an area for a specified period of time during the growing season to promote plant reproduction, establishment of new plants, or restoration of vigor by old plants.

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[1]These definitions are taken from A Glossary of Terms Used in Range Management (American Society of Range Management, 1964).

DEFERRED ROTATION GRAZING. Discontinuance of grazing on various parts of a range in succeeding years, allowing each part to rest successively during the growing season to permit seed production, establishment of seedlings, or restoration of plant vigor. Two, but usually three or more, separate units are required. Control is usually insured by unit fencing, but may be obtained by camp unit herding.

FORAGE. (N) All browse and herbaceous food that is available to livestock or game animals. It may either be used for grazing or harvested for feeding. (V) Act of consuming forage.

GRAZING DISTRICT. An administrative unit of Federal range established by the Secretary of Interior under the provisions of the Taylor Grazing Act of 1934, as amended. Also, an administrative unit of state, private, or other rangelands, established under certain state laws.

GRAZING LICENSE OR PERMIT. Official written permission to graze a specified number, kind and class of livestock for a specific period on a defined allotment.

GRAZING SYSTEM. The manipulation of livestock grazing to accomplish a desired result.

HABITAT. The natural abode of a plant or animal, including all biotic, climatic, and soil conditions, or other environmental influences affecting life.

MULTIPLE USE. Harmonious use of range for more than one of the following purposes: grazing of livestock, wildlife production, recreation, watershed, and timber production. Not necessarily the combination of uses that will yield the highest economic return or greatest unit output.

RANCH. An establishment with specific boundaries, together with its lands and improvements, used for the grazing and production of domestic livestock.

RANGE. All land producing native forage for animal consumption, and lands that are revegetated naturally or artificially to provide a forage cover that is managed like native vegetation. Generally considered as land that is not cultivated. In Taxonomy, the area or areas throughout which a plant or animal taxon occurs.

RANGE IMPROVEMENT. (Physical) Any structure or excavation to facilitate management of range or livestock. (Biological) An increase in the grazing capacity of range. Improvement in range condition.

REST-ROTATION GRAZING. An intensive system of management whereby grazing is deferred on various parts of the range during succeeding years, allowing the deferred part complete rest for one year. Two or more units are required. Control by fencing is usually necessary on cattle range, but may be obtained by herding on sheep ranges.

ROTATION GRAZING. Orderly sequence of use when each subdivision is both grazed and deferred during the same grazing season or calendar year.

ROTATIONAL DEFERMENT. A grazing system in which one or more parts of the range are rested during the growing season each year; and rotational use of other segments of the range are not necessarily planned for.

WILDERNESS. An uncultivated, relatively uninhabited region usually in an undisturbed condition.

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